POWER

Vol. 41 NEW YORK, FEBRUARY 2, 1915 No. 5

The Leak

By R. T. Strohm

THE boss was good and proper mad, of that there was no doubt,
When he came in the other week to see the engineer.
He hardly got inside the door before we heard him shout
"Just look at this report on cost of power for the year!
The way you're running up expense has simply got to stop,
Or you'll be gallivanting 'round in search of pastures new.
Another year like this one was will make us close the shop.
Get busy, now, and find the leak —the thing is up to you!"

"The boss was good and proper mad"

THE engineer was young and fresh, an overbearing snob,
Who always tried to make us feel that he was mighty wise;
So when we heard the sudden news that he might lose his job,
We nudged each other in the ribs and slyly winked our eyes.
For we were in the boiler room, to cart and heave the coal,
To clean the tubes and haul the ash, and tend the water, too;
And every mother's son of us, deep in his inmost soul,
Felt pretty sure that half the heat was going up the flue.

"The engineer was young and fresh"

HE snooped around in every nook and tested all the traps.
To see that they were working well and steam could not get by;
He tinkered with the bearings and adjusted all the caps,
Believing that the friction loss was running rather high;
He packed the engines and the pumps to make them good and tight,
And then relined the shafting till it ran exactly true;
But we that fed the furnaces from early morn to night
Were puzzled why he never thought to test for CO_2.

"Half the heat was going up the flue"

HE poushed all the pieces of his indicator kit
And took a set of cards from every engine on the floor;
He looked them over carefully and set the valves a bit,
And then he fixed the rig again and took a dozen more;
He overhauled the coverings on pipes conveying steam,
And every broken section was replaced at once with new;
He tried to lower running costs by every kind of scheme,
But never thought to make a test of what went up the flue.

HE fussed and fumed and stewed around about a week or so,
But still the coal-pile dwindled down alarmingly each day;
So finally we told him what we thought he'd like to know,
And said he'd better find just how much heat we threw away.
That hint was what he needed, for, instead of cutting loose,
He clinched his job still tighter, and he saved our bacon, too.
And thus he proved the adage that it's precious little use
To save around the engine while you're wasting up the flue.

Municipal Pumping Stations of Detroit

By Thomas Wilson

SYNOPSIS—Development of water-works from one unit in 1876 to ten units at present date, having a combined capacity of 267,000,000 gal. in 24 hr. New station containing three units just completed. Operating data and costs for the past year.

For 38 years Detroit's water-pumping station has been located in Waterworks Park at the eastern extremity of the city, between Jefferson Ave. and the river. Starting with one unit, the development to present capacity has been interesting. New units were installed as required until seven are now contained in the old station and three in a new building in which space has been provided for a total of six. Individually, each unit shows an increased duty over its predecessor, and collectively, the entire installation indicates the development in the art.

In the installation of large units Detroit has been a pioneer in pumping engines as well as in boilers, and it may be of interest to follow the plant through from the beginning. In 1876 a building large enough for two units was erected, and the first unit, a compound beam double-acting pumping engine having a capacity of 24,000,000 gal. per 24 hr., was installed. The cylinder dimensions were 42 and 84 by 40¼ by 72 in. In those days a compound engine was a novelty, and as the unit had almost double the capacity of any pump then in existence, it created wide interest and, like the Centennial engine, was one of the attractions in the engineering world. It showed a duty of 87,000,000 ft.-lb. on 100 lb. of coal, the steam pressure being 65 lb. gage and the speed 10½ r.p.m. It was the only pump of the kind ever built by the Detroit Locomotive Works. That it was of good design and well made is shown by the fact that it is still in active service.

A unit of similar design and of equal capacity and duty was installed in 1880. The dimensions were 46 and 84 by 41 by 72 in. Six years later another unit was required and the east end of the station was enlarged to make room for it. At this time Detroit's original pumping station was dismantled and as many parts as possible were saved for the new unit, which was to have a capacity of 30,000,000 gal. The pump thus had a capacity 25 per cent. greater than its predecessors, and was one of the "giants" of its day. It had compound steam cylinders and a water plunger of the same diameters as unit No. 2, but the stroke was 84 in. and the speed higher. The economy was also greater, as the pump showed a duty of 100,000,000 ft.-lb. In 1898 the high-pressure end was redesigned for a 35-in. high-pressure cylinder, so that the pump could utilize steam at 135 lb. pressure instead of 65 lb., the pressure formerly carried.

After an interval of seven years increasing demands called for a fourth unit, which was put in service in 1893. The west end of the station was enlarged to receive it. The pump was the first triple-expansion unit for the station, with cylinders 28, 48 and 74 by 36 by 60 in. It had a capacity of 24,000,000 gal. and was a duplicate of one pumping engine installed in Milwaukee and three in Chicago at the same time. Outside-packed plungers were another departure. A 30-day test by Professor Barr on this unit showed a duty of about 130,000,000 ft.-lb., an increase in economy of 33⅓ per cent. over the most efficient of the compounds which had been previously installed.

Up to this time the pumps had been working against a head of 140 ft., or 60 lb. Need was felt for a higher pressure, so the next units were designed to operate against a head of 230 ft., or nearly 100 lb. pressure. The east end of the station was again enlarged, this time for three units. In 1900 two 25,000,000-gal. pumps were installed. They were triple-expansion units, 34, 62 and 92 by 36½ by 72 in., which on test showed a duty of 148,000,000 ft.-lb. These two units, as well as Nos. 3 and 4, operate on 135-lb. steam pressure. All up to this point had been equipped with jet condensers giving a vacuum of 26 in., the air pump being driven from the main shaft.

Fig. 1. New Pumping Station in Waterworks Park, Detroit

Eleven years passed before the seventh unit was needed. It was ordered in 1911 and was built and installed in the remarkable time of eight months after the contract was signed. The capacity was 25,000,000 gal. and the type vertical triple-expansion as before. The dimensions were 32, 60 and 90 by 37½ by 66 in. Since the last previous installation a surface condenser in the suction of the pump had become common practice, and was used in the present case. A surface of 2000 sq.ft. exposed to all of the water passing to the pump produced a vacuum of 28 in. and helped to boost the duty of this unit to 150,000,000 ft.-lb. and cut the steam consumption to 10.3 lb. per i.hp.-hr. This arrangement naturally eliminated the circulating pump.

Boiler Room

In the boiler room equal progress was made in the size and efficiency of the equipment. Old firebox marine and return-tubular boilers, hand-fired, have been replaced with water-tube boilers of horizontal and vertical types equipped with top feed or underfeed stokers. There is now a total of 15 boilers aggregating 4399 hp. There are four 225-hp. horizontal boilers on which the pressure has been cut to 110 lb., three 333-hp., four 225-hp. and four

400-hp. vertical boilers, all carrying a working pressure of 165 lb. The 400-hp. boilers were installed in 1913. Each has 4000 sq.ft. of heating surface and 64 (later reduced to 50) sq.ft. of inclined grate surface. The high ratio of 80 to 1 was made possible by the excellent quality of coal used, which is Meadow Brook run-of-mine averaging 14,300 B.t.u. per lb. and 6 to 7 per cent. ash. Four brick stacks for the 15 boilers supply natural draft. Gages to measure the draft, a steam-flow meter and a CO_2 recorder make it possible to check results obtained from the boilers.

Fuel is obtained by boat during the navigation season. It is unloaded into a hopper, crushed, and conveyed to storage sheds of 12,000 tons capacity. Industrial cars carry the coal into the boiler room where, with the exception of the new boilers, it is shoveled into the magazines of the stokers. For the late addition a half-ton air hoist transfers the coal from car to stoker.

Water from the jet condensers and the steam jackets of the engine cylinders is discharged to hotwells at a temperature of 140 deg. and fed to the boilers by single-acting pumps operated from the walking beams or the main shafts of the first six units. The pumps discharge into a common header tapped to each boiler. Feed-water regulators control the supply to the boilers, and as the pumps operate in unison with the main units, safety valves are installed on the discharge pipes to prevent excessive pressure and allow surplus water to flow back to the hotwell. Feed-water heaters are not used, as there is no auxiliary steam. This completes the equipment of the old station, which was given in some detail so that it might be known from what type of machines the operating data presented later were obtained.

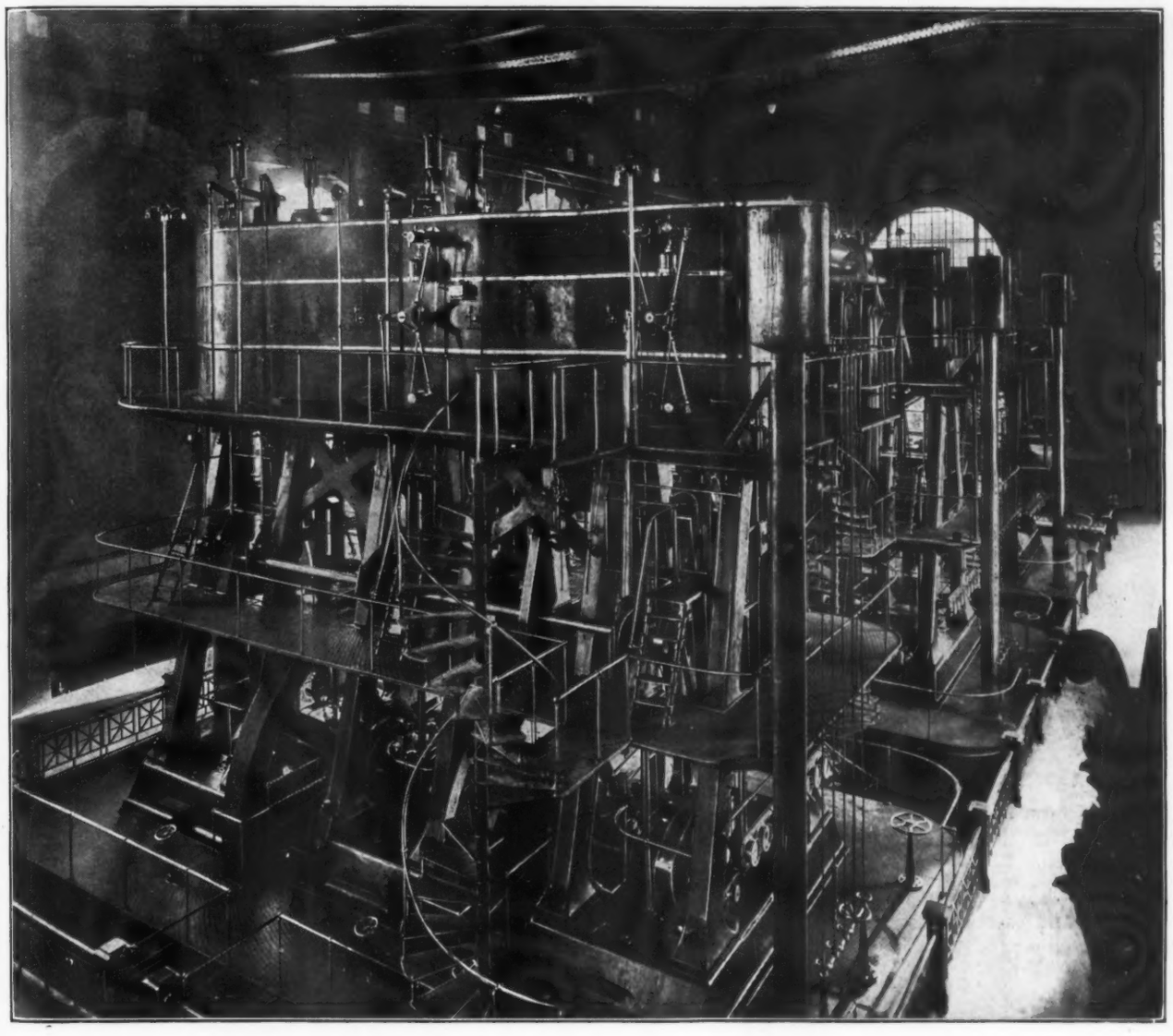


FIG. 2. THREE 30,000,000-GAL. PUMPING ENGINES OCCUPYING HALF THE STATION

NEW PUMPING STATION

In 1909 the water commission broke ground for the new station which rapidly increasing demands made necessary. The building, which has just been completed, was planned for six units, being 300 ft. long and 75 ft. wide. It is one of the finest structures of its kind in the country. Concrete foundations, walls of cut stone and pressed brick, a marble entrance, large bronze doors, electroplated railings around the pits, massive lighting fixtures, slate and terrazo floors and white enamel brick walls in the basement are some of the features which helped to make the building cost half a million dollars.

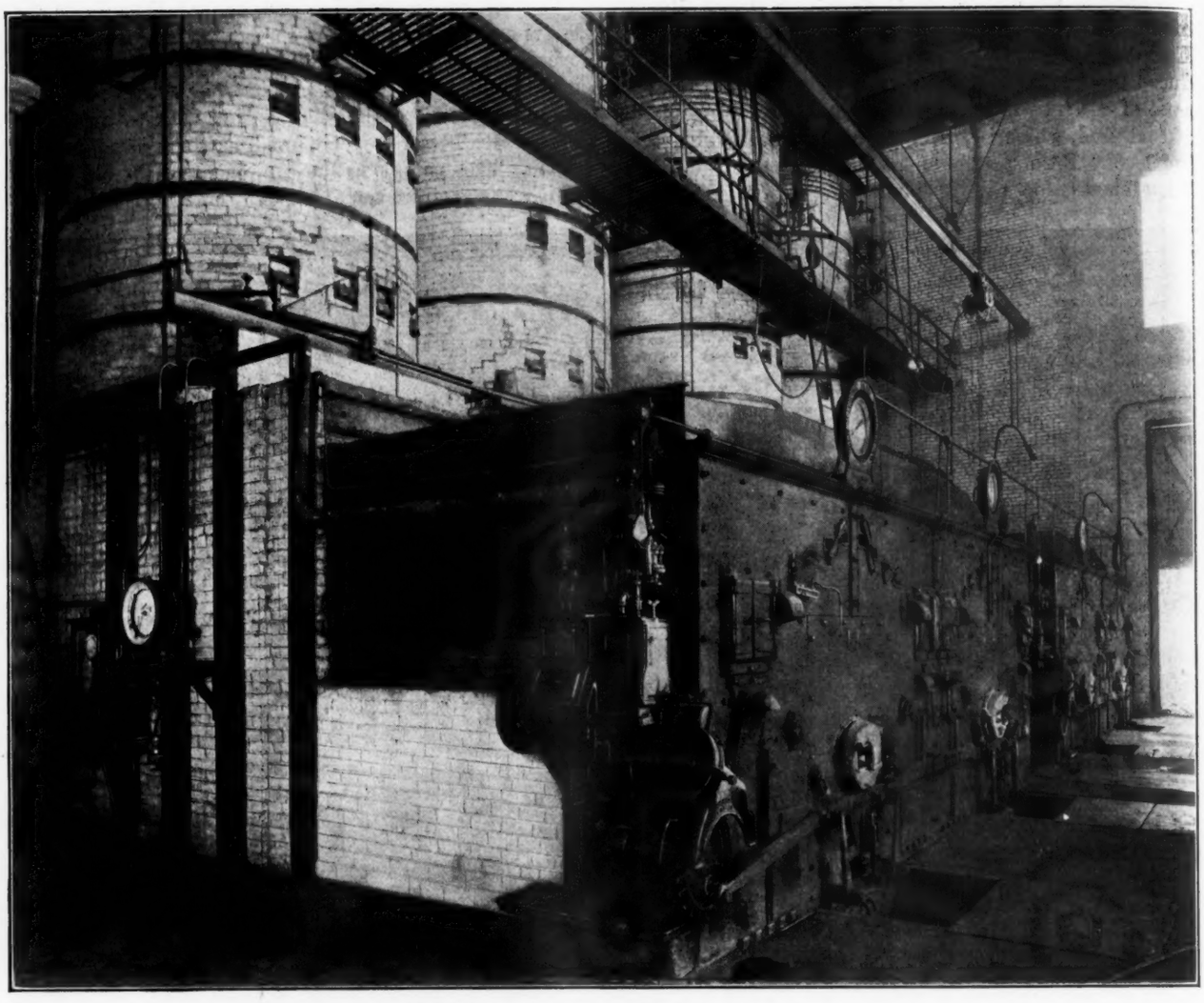


FIG. 3. FOUR 400-HP. VERTICAL WATER-TUBE BOILERS INSTALLED IN 1913

Three of the six units for this building have just been erected and put into service. All are triple-expansion engines of 30,000,000-gal. capacity, with cylinders 32, 60 and 90 by 39¾ by 66 in. The pumps are of the double-flow type and each has on the suction side a condenser having 2000 sq.ft. of surface. Hydraulically operated gate valves 48 in. in diameter are fitted to the suction and discharge pipes. Each pump weighs approximately 900 tons, of which 70 tons is accounted for by two 20-ft. flywheels. The hollow steel shaft is 22 in. in diameter. A feature is the making of the water ends entirely of cast steel. Extra strength was required, as the water is delivered directly to the mains, with no intervening reservoirs. No official tests have been conducted, but the duty guaranteed on 1000 lb. of saturated steam is 172,000,000 ft.-lb., and 180,000,000 ft.-lb. is expected by the builder. The cost of the pumping equipment was close to $3700 per million gallons of daily capacity.

PRINCIPAL EQUIPMENT OF DETROIT WATER-WORKS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Pumping engine	Compound, beam	42x84x40¼x72-in.	Main unit	Steam pressure 65 lb., head 60 lb.	Detroit Locomotive Works
1	Pumping engine	Compound, beam	46x84x41x72-in.	Main unit	Steam pressure 65 lb., head 60 lb.	Riverside Engine Works
1	Pumping engine	Compound, beam	35x84x41x84-in.	Main unit	Steam pressure 135 lb., head 60 lb.	Riverside Engine Works
1	Pumping engine	Triple expansion	28x48x74x36x60-in.	Main unit	Steam pressure 135 lb., head 60 lb.	E. P. Allis & Co.
2	Pumping engines	Triple expansion	34x62x92x36½x72-in.	Main unit	Steam pressure 135 lb., head 100 lb.	Allis-Chalmers Co.
1	Pumping engine	Triple expansion	32x60x90x37½x66-in.	Main unit	Steam pressure 165 lb., head 100 lb.	Allis-Chalmers Co.
3	Pumping engines	Triple expansion	32x60x90x39½x66-in.	Main unit	Steam pressure 165 lb., head 100 lb.	Bethlehem Steel Co.
6	Condensers	Jet		Serving main units	26-in. vacuum	Same as pumping engines
6	Air pumps	3 single-acting, 3 double	Varying sizes	Serving jet condensers	Direct-connected—Speeds 12 to 21 r.p.m.	Same as pumping engines
4	Condensers	Surface	2000 sq.ft.	Serving main units	28-in. vacuum	3 Bethlehem engines—Worthington condenser; 1 Holly engine—Holly condenser
6	Pumps	Single-acting	Varying sizes	Boiler feed	Mechanically driven by main units	Same as main units
3	Boilers	Vertical water-tube	333 hp.	Generate steam	Steam pressure 165 lb., stokers	Wickes Boiler Co.
3	Stokers	Jones underfeed		Serving 333-hp. boilers		Under-Feed Stoker Co. of America
4	Boilers	Wood type	225 hp.	Generate steam	Steam pressure 110 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed		Serving wood boilers		Murphy Iron Works
4	Boilers	Vertical water-tube	225 hp.	Generate steam	Steam pressure 165 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed		Serving 225-hp. boilers		Murphy Iron Works
4	Boilers	Vertical water-tube	400 hp.	Generate steam	Steam pressure 165 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed	50 sq.ft. grate	Serving 400-hp. boilers		Detroit Stoker Co.
1	Air hoist	Monorail	½-ton	Serving 400-hp. boilers		Detroit Machine & Hoist Co.
2	Cranes	Traveling	30 and 20 tons	In new and old stations		Northern Engineering Works

Although an independent boiler room and coal-storing sheds are contemplated for the new station, at present steam is supplied from the boiler room of the older plant, the new 400-hp. boilers giving ample capacity; a total of 4399 boiler-horsepower in 15 boilers supplying 10 pumping engines having a combined capacity of 267,000,000 gal. in 24 hr. against a varying head running up to 100 lb. Thus, for a million gallons in 24 hr., 16.5 boiler-horsepower has been provided. Working on 8-hr. shifts, 65 men are employed for both stations.

Operating Data

Data available from the Board of Water Commissioners for the year ended June 30, 1914, are presented in the following: For the year the total water consumption was 40,724,947,672 gal. pumped to an estimated population of 652,000 against an average head of 53.2 lb. This reduces to an average daily consumption of 111,575,200 gal. and an average daily per capita of 171.4 gal. Of the total, 11,257,814,355 gal. was pumped on the high service against an average dynamic head of 63.7 lb., and on the low service 29,467,133,317 gal. against an average head of 47.4 lb. On Feb. 13, the maximum day, the pumpage was 145,607,536 gal., and on Dec. 25, the minimum day, 85,187,023 gal. For the high service the average daily was 30,843,327 gal. and for the low service 80,731,872 gal.

Each unit is equipped with a Venturi meter, which, on an average, reads to within 5 per cent. of the pump displacement. In the above figures an allowance of 6 per cent. slip was made for the three compounds and one triple-expansion engine and 5 per cent. on the other units.

During the year 46,874,865 lb. of Meadowbrook bituminous run-of-mine coal was burned. Including unloading from the boats, the price averaged $2.515 per ton. Per pound of coal 869 gal. was pumped against an average head of 53.2 lb. or 123.7 ft. The average duty per 100 lb. of coal was 88,906,868 ft.-lb. The pumping cost based on station expenses is given in the accompanying table. The total for the year is $136,000.38. This reduces to $2.72 per million gallons raised 100 ft. Figured on total maintenance, the cost per million gallons was $6.23.

COST OF PUMPING BASED ON STATION EXPENSES

Item	Amount per Year	Cost per Mil. Gal.	Cost per Mil. Gal. Raised 100 Ft.
Pay roll	$67,533.31	$1.66	$1.35
Fuel	59,103.57	1.45	1.18
Oil and waste	1,446.76	0.04	0.03
Supplies and repairs	4,359.97	0.11	0.09
Miscellaneous	3,556.77	0.08	0.07
Totals	$136,000.38	$3.34	$2.72

Smith, Hinchman & Grylls, of Detroit, were the architects and engineers for the new station. Theodore A. Leisen is general superintendent of the Board of Water Commissioners and H. W. Gould engineer-in-charge of the pumping station. To both of these officials we are indebted for the information contained in this article.

The Constant-Current Transformer

By John A. Randolph

SYNOPSIS—Principles and construction of the constant-current transformer, with a diagram of its connection to arc-light circuits.

On all series arc systems it is important that the current be maintained constant irrespective of how many lights may be turned on or off. This is accomplished on direct-current systems by varying the voltage of a special generator assigned to each circuit. However, on alternating-current systems the arc lines are generally connected to busbars supplying other circuits, hence the maintenance of the constant current must be accomplished without affecting the generator pressure on the busbars. To secure this result, a special form of transformer is used. It is similar to the ordinary static transformer, the principal difference being that one of its sets of coils is movable.

Construction

The general construction is shown in Fig. 1. The transformer contains two coils, a primary and a secondary, one of which (in this case the primary) is stationary, the other being movable. The coils encircle the middle leg of a laminated iron core of the double magnetic-circuit type, the length of the core being sufficient to allow the secondary to move up and down through the required range. The secondary is suspended on either side from a rocker-arm attached to a shaft, which in turn is connected at its middle point to another arm extending oppositely to the other arms and which carries an adjustable weight. An oil-filled dashpot is also attached to the shaft for the purpose of steadying the movements of the shaft and its accessories.

Operation

In analyzing the operation, consider two simple closed coils of wire P and S placed side by side with axes coincident, as shown in Fig. 2. If a current is passed through coil P, it will produce a magnetic field which will expand with the rise of the current. As these lines of force move outward they will be cut by the coil S. Now, according to the laws of electromagnetic induction, this

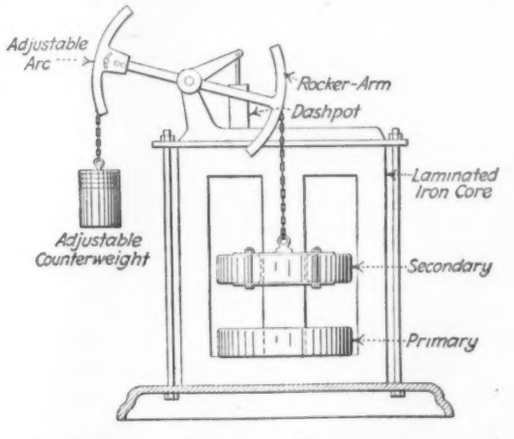


Fig. 1. Showing General Construction of Constant-Current Transformer

cutting of lines of force will induce a current in the coil S, the direction of which will be opposite to that in coil P. This induced current will in turn set up a magnetic field of its own, but it will be opposite in polarity to that of coil P, owing to the opposite direction of the respective currents. A magnetic repulsion will therefore ensue between coils P and S. This action has been summarized in Lenz's law as follows: "In all cases of electromagnetic induction the reaction of the induced current is such as to tend to stop the motion which produces it." It is

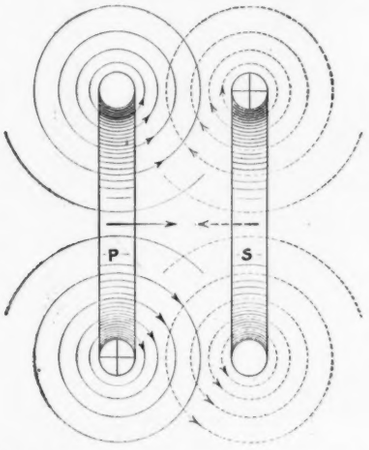


FIG. 2. ILLUSTRATING PRINCIPLE OF THE CONSTANT-CURRENT TRANSFORMER

upon this principle that the operation of the constant-current transformer depends.

The counterweight in the two-coil type, shown in Fig. 1, is adjusted to exactly balance the weight of the secondary coil minus the repulsion, thereby rendering the transformer sensitive in its action and overcoming to a large extent the attraction of the force of gravity on the coil. The secondary coil is connected directly to the outgoing arc lines and the primary to the busbars. It can be said in general that the repulsion between the primary and the secondary will vary with the current in the latter. If, with the secondary coil in a given position, an additional number of lamps is turned on, the added series resistance will at once reduce the current for that particular instant. This will result in a decrease of the reaction of the secondary upon the primary, thereby allowing the secondary to fall nearer the primary, where the stronger field will induce the extra pressure necessary for maintaining a constant current in the secondary. The turning off of lamps will cause an instantaneous increase in the secondary current, which will increase the repulsion and cause the secondary to move to a weaker field, where the voltage will be lowered sufficiently to prevent any rise of current in the lamps that remain burning.

It will be observed in Fig. 1 that the arc on the end of the rocker-arm which carries the counterweight is adjustable. This is for the purpose of compensating for the difference in field strength in the various positions of the secondary. For instance, in a strong portion of the field, the difference between the weight of the secondary and the force of repulsion is less than in a weaker part of the field. Therefore, unless the counterweight were adjusted to balance this added weight in the weaker field, a stronger current would be necessary in the secondary to shift the latter to a position of equilibrium than would be required in the stronger field. The constancy of the current in the arc circuit would therefore be destroyed. However, by the adjustment of the arc from which the counterweight is suspended, the latter is caused to pull more heavily on the secondary in the weaker parts of the field, thereby enabling the secondary to maintain a constant-current value.

THREE-COIL TYPE

As the capacity of the transformer increases, the number of ampere-turns in the primary and the secondary must also increase. Therefore, if only two coils were used, this would result in bulky windings and accessories which it would be difficult to handle and which would be likely, on account of their inertia, to lack the proper sensitiveness in operation. To obviate these difficulties three or four coils are used instead of two. In the three-coil type one primary and two secondaries are used, as in Fig. 3. Large pulleys are used instead of levers for the chain connections to the counterweights. The primary is stationary and is placed between the two secondaries, which are movable. Each secondary has two pulleys and a counterweight of its own and is entirely independent of the other in its action. Therefore, the repulsion and the distance between coil S_1 and the primary may be widely different from that between coil S_2 and the primary. Arc circuits may therefore be operated on the two coils in entire independence of each other. To increase the current in coil S_1, the external resistance remaining the same, the weight W_1 is reduced, allowing the coil by means of gravity to move nearer the primary. On the other hand, to increase the current in coil S_2, the counterweight W_2 must be increased in order to overcome the force of gravity and raise the coil to a position nearer the primary.

FOUR-COIL TYPE

In this transformer the primary and secondary are each composed of two coils, both coils of one set, either

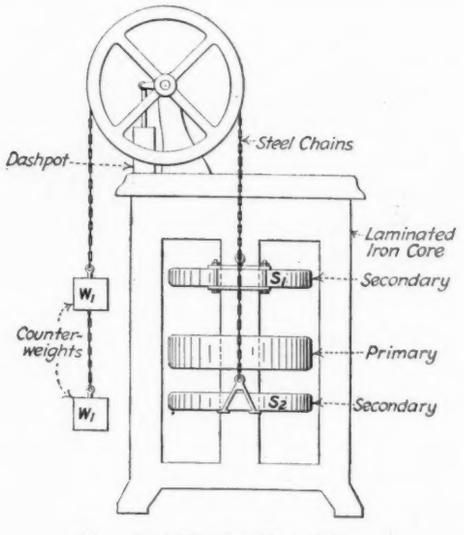


FIG. 3. THREE-COIL TYPE

primary or secondary, being movable. In Fig. 4 is shown the arrangement of coils where the secondary is movable. The two primary coils are fixed at the extremities of the middle leg of the laminated iron core, the secondaries being free to move up and down in the intervening space. A repulsion between the primary and the secondary causes the two coils of the latter element to

move toward the center of the core, thereby approaching each other. The movable coils are balanced against one another on two double levers, A and B, one end of lever A being connected to coil S_1 and the other to coil S_2. Likewise, lever B is connected to the other sides of coils S_1 and S_2. With this arrangement the secondaries will exactly balance each other when no external force is applied. This equilibrium, however, is destroyed as soon as a force of repulsion is set up between primary and secondary. To counterbalance this repulsion and regulate the movements of the secondaries, a counterweight is attached to the lever system. This has a tendency to bring the primary and the secondary coils together and is set to counterbalance the repulsion for a given current. As in the case of the two-coil transformer, the counterweight is supported on an adjustable arc to compensate for the difference in field strength in the various parts of the magnetic circuit.

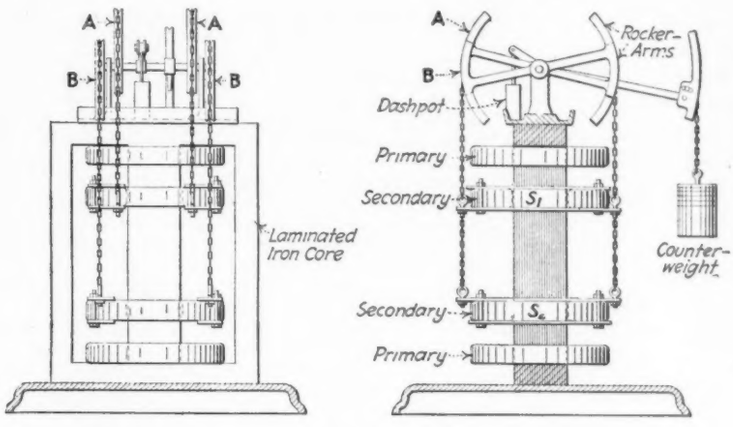


FIG. 4. ARRANGEMENT OF FOUR-COIL TYPE WITH MOVABLE SECONDARIES

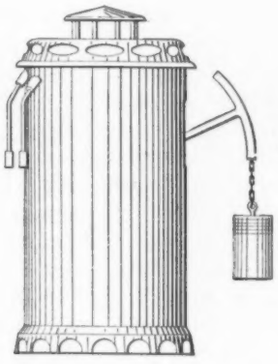


FIG. 5. CASING OF AIR-COOLED TRANSFORMER

INSTALLATION AND CONNECTIONS

Constant-current transformers are made in both the air-cooled and the oil-cooled types. When of the former pattern, all the parts except the counterweight are inclosed in a suitable sheet-iron case, as shown in Fig. 5, with liberal openings at the top to provide the necessary ventilation. Large openings are also left in the bedplate for the same purpose. In the oil-cooled type all the interior parts are placed in a tank and covered with oil, its external appearance being similar to that of the ordinary oil-cooled static transformer.

A diagram of connections commonly followed in the use of the constant-current transformer on three-phase systems is shown in Fig. 6. In the case shown the transformers are of the larger type containing two primaries and two secondaries, and the windings are connected for full load. However, it is sometimes desired to operate on partial loads, under which conditions, owing to the inductance of the primary coils, the power factor would be considerably reduced were the full winding used. To obviate this difficulty and thus maintain the efficiency of the system, taps are provided on the primary whereby part of the winding may be cut out, thus reducing the inductance and raising the power factor. Taps are also generally provided in the secondary coils for the same reason.

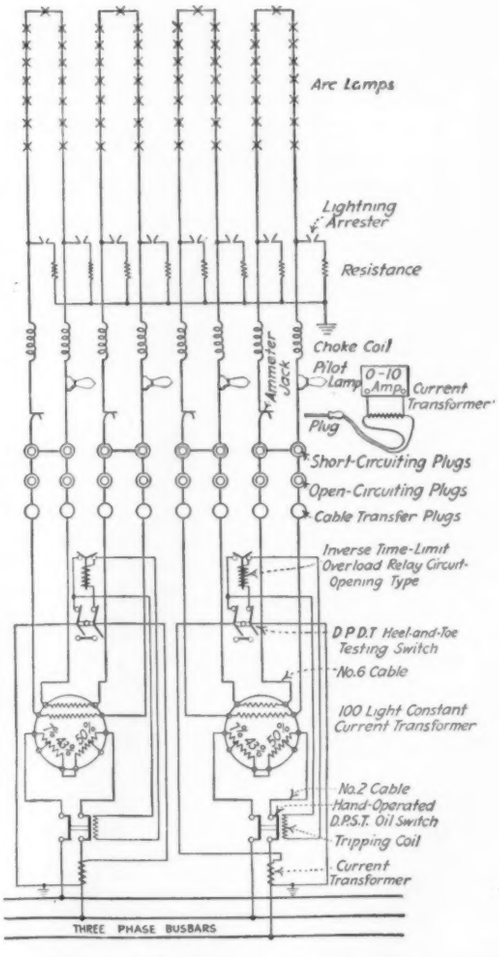


FIG. 6. TYPICAL DIAGRAM OF CONNECTIONS FOR CONSTANT-CURRENT TRANSFORMERS

For opening and closing the primary circuit, either plug switches or oil switches may be used, but it is common practice to use the latter because of greater convenience in operation and the fact that they will open automatically if a sudden abnormal load is thrown on the transformer through a short-circuit, a ground, a lightning discharge or other disturbance. This tripping of the switch is accomplished by a relay which receives its

excitation from a current transformer in one of the primary leads.

Cable transfer plugs are provided in the secondary lines for the purpose of transferring the load on any line to another circuit. This provides a convenient flexibility in the system in case of repairs and other contingencies. The open-circuiting plugs are for the purpose of disconnecting the various circuits from their respective transformers. The short-circuiting plugs enable one of the two circuits of each transformer to be disconnected from the system without affecting the operation of the other.

An ammeter is provided on the arc panel to give current readings on the various circuits. To enable the customary low-voltage switchboard ammeter to be used, a current transformer is placed between the ammeter and the line, thereby preventing the high voltages of the line from coming in direct contact with the ammeter. The transfer of the instrument from line to line is accomplished by means of a plug attached to a flexible cord. The plug is inserted into a jack or receptacle attached to one leg of the respective circuits. As an additional means for providing current indications, a pilot lamp is connected in series with each circuit. This furnishes an approximate indication when the ammeter is disconnected.

Choke coils are placed in the various lines for the purpose of forcing lightning discharges to jump to ground through the lightning arresters, thus protecting the station apparatus.

It will be observed that larger wire is used on the primary side of the transformer than on the secondary. This is because on the heavier loads the primary, owing to its constant voltage, may be taking a heavier current than the secondary whose current never varies and is usually about ten amperes.

The efficiency of the constant-current transformer, when operating under full load, ranges from 94 per cent. in the smaller sizes to 96 per cent. in those of larger capacity.

Examining the Examiner

In connection with the selection and appointment of the members of the Steam Engineers' and Boiler Operators' Licensing Bureau recently authorized by the State of New Jersey, the impression has been created that the questions asked by the Civil Service Commission of candidates to membership on the Board of Examiners were abstruse and technical to such a degree that no practical engineer could be expected to answer them. We have obtained from the Board the list of questions used at the examination which has been most discussed. Here they are. Is there a question in the list which one who aspires to be a state examiner of engineers should not be able to answer?

GENERAL QUESTIONS

A. State your experience, giving a complete record of where you have been working the last ten years; stating the size and make of each engine and boiler that you had under your jurisdiction, also giving name of the man, with his title, to whom you reported.

B. Write out five questions which you would suggest as desirable to use in examining a candidate for a first-class engineer's license.

C. Describe fully what you believe would be a correct method to use in forming different grades for engineers' and firemen's licenses.

Note: Candidates may ask examiner for explanation of any question that is not understood.

WRITTEN TECHNICAL QUESTIONS

1. Show by a sketch how a (one) steam main should be arranged in a boiler room in which there are two 200-hp., 160-lb. pressure boilers and two 100-hp. 100-lb. pressure boilers, so that at times all boilers might be put in service at 90-lb. pressure, or, each may be used at its respective pressure. Indicate all valves, reliefs, safetys, etc.
2. Calculate the horsepower of a boiler plant that burns 35 lb. of coal per square foot of grate per hour under boilers containing 10,000 sq.ft. of heating surface. Ratio of heating surface to grate surface = 50:1. Heat units in coal = 15,000 B.t.u. per pound. Efficiency of burning coal in boiler = 60 per cent.
3. Show by a sketch a triple-riveted butt-strap joint, and explain why longitudinal seams are butt-jointed and girth seams are lap-jointed.
4. A flat plate, 16x12 in. is held against a tank by four 1-in. bolts; what is the safe pressure to use in the tank, assuming factor of safety 5, tensile strength 50,000 and diameter root of thread = ¾ in.?
5. Show the arrangement of tubes, doors, etc., indicating the location of grate, smoke flue and baffles, for
   (a) Babcock & Wilcox cross-drum boiler
   (b) Stirling boiler
   (c) Heine boiler
   (d) Horizontal return-tubular boiler
6. (a) How many square feet of grate should there be for a 500-hp. boiler burning soft coal?
   (b) How large a piston should there be in an engine to develop 500 hp., if the mean effective pressure is 100 lb. and the piston speed is 250 ft. per min.?
7. If the eccentric of an engine is set so that it has an angle of advance of 28 deg., and if it is desirable to change the direction of rotation of engine, exactly how many degrees would you move the eccentric and in which direction, so that the angle of advance would still be 28 deg.?
8. How could you increase the operating speed of a fly-ball governing Corliss engine and yet have the "cutoff" the same?
9. If a cross-compound engine was out of adjustment how would you proceed to correct the steam distribution, so that equal work would be done on both cylinders?
10. Explain in detail how you would proceed to erect a girder-frame engine so that it would be level, true and aligned up to connect to a flange on a shaft already installed.
11. (a) What is meant by "clearance" of an engine?
    (b) How could you determine the location of the piston in respect to the ends of the cylinder, without removing the heads?
    (c) At which end of the stroke should the greater distance to the cylinder head be allowed? Why?
12. Show by a sketch how the exhaust-steam piping should be arranged for an engine operating with a surface condenser, indicating all valves, reliefs, etc.

Note: An examiner was present during the examination to explain any question that was not understood by candidates.

ORAL QUESTIONS

The candidate upon finishing the above set of questions will be examined orally on practical questions submitted to him in the engine and boiler room.

The candidate may answer the questions orally, or by demonstration.

Note: The general questions asked the last candidates were in connection with the following:

Cross-Compound Corliss Engine with Flyball Governor

1. Trace path of steam through the engine.
2. Explain the use of pipe pointed out (atmospheric relief pipe for high-pressure cylinder).
3. Examine, and explain completely the action of the engine governor.
4. Explain why the engine would not speed up if the governor belt broke.
5. Explain the use and principle of operation of the dash-pot.

High-Speed Vertical Compound Engine, Double Acting

6. Examine, and state type of engine.

Single-Cylinder Horizontal Engine, with Inertia Governor

7. Explain operation of the governor on the engine shown.

Vacuum Pump

8. Examine, and state what the piece of apparatus pointed out is used for.

Worthington Surface Condenser

9. Examine, and state what the piece of apparatus pointed out is used for.

Open-Type Feed-Water Heater

10. Examine, and state what the piece of apparatus pointed out is used for.
11. Is the heater shown an open or closed type?

Forced-Draft Apparatus (Engine and Centrifugal Fan)

12. Explain the use of the apparatus pointed out.
13. Does the engine have a lighter load with the forced-draft slides entirely closed, or with them entirely open?

Pressurlokd Water Gage

This water glass is so designed that the boiler pressure is used to lock the registering glass, which prevents the glass from flying should it break, and also prevents the escape of hot water and steam. A sectional view is shown in Fig. 1.

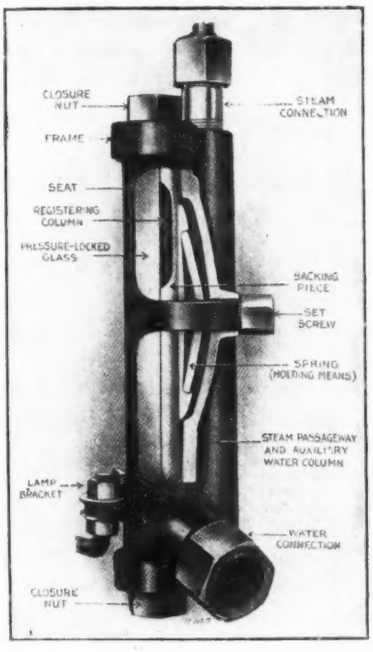


FIG. 1. DETAILS OF PRESSURLOKD WATER GAGE

The oufit consists of a metal-gage frame in which the registering glass *A*, Fig. 2, is held in place by a metal-sealed joint *C* to the seat *H*, by a back piece *N* and a holding spring *I*. The interior parts are held in place by a setscrew *L* which, when screwed down to its copper sealing washer, puts the proper tension on the spring. This tension, supplemented by the steam pressure at the points *D*, holds the backing piece and metal-incased glass to its seat on the inside of the frame, thus pressure-packing the metal-sealed joint. The steam pressure around the sides *EEK* and on the ends of the metal-incased glass locks the glass. Should the glass crack, the external pressure on the side and ends presses the shattered pieces closer together, which prevents leakage and the flying of glass.

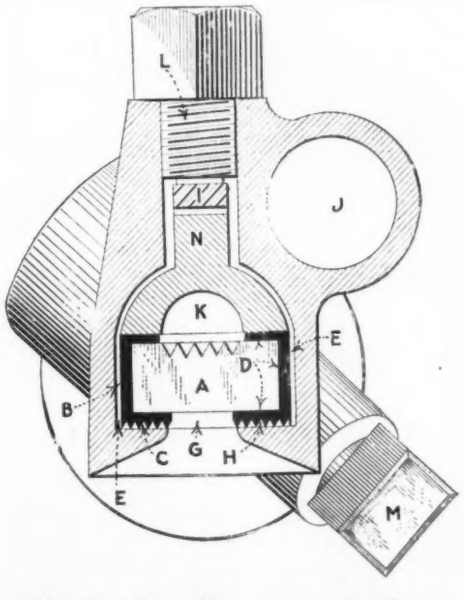


FIG. 2. CROSS-SECTION OF THE GAGE

The registering glass is incased with a sealing metal *B*, with the exception of the sight opening in front and the reflex part at the back. The metal frame seats on the serrated front *C* of the metal casing around the sight opening *G* inside of the frame. The spring which holds the glass to its seat permits it to expand and contract on its seat, thus relieving it of strains.

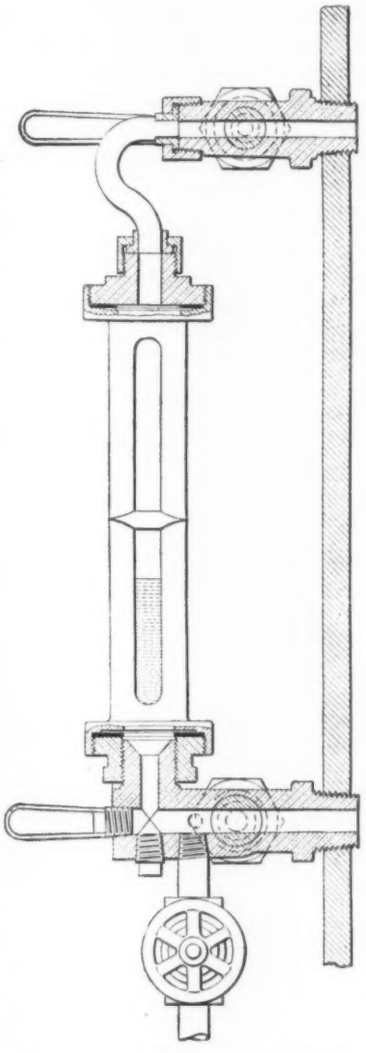


FIG. 3. UNIVERSAL GAGE FOR ANY BOILER

The space *K* back of the glass communicates with the water space *J*, and to the boiler through water and steam passageways. The steam and water connections to the boiler are straightway and, as no separate water column is used with the glass, straightway valves are used in the connections. Each valve is fitted with a semaphore handle, which shows whether the valve is open or closed. *M* is a cleaning plug.

The universal type of water glass, designed for any type of stationary boiler, is shown in Fig. 3. It contains the features of the locomotive type (Fig. 1) and is provided with a separate steam passageway, no water-column reservoir being used.

In case the glass breaks, the closures at the top and bottom of the frame are unscrewed, the setscrew is released and the old glass removed. When the new glass is inserted the setscrew is turned to its seat, copper gaskets inserted and the closures replaced.

These water gages are manufactured by the Prince-Groff Co., 50 Church St., New York City.

In "The Year's Review," published in our issue of Jan. 5, we failed to mention that the first unaflow engine built in this country under Professor Stumpf's patents and under the supervision of his American representatives, was erected at Auburn, N. Y., by the Ames Iron Works. We are glad to learn that the success of this first engine has led to numerous orders, and hope soon to be able to describe a considerable installation.

Power Requirements of Ammonia Compressors

By W. N. McKee

SYNOPSIS—An explanation of the use of charts for determining the power requirements of ammonia compressors for different suction and discharge pressures.

The power required to drive ammonia compressors is a constantly varying quantity due to the many operating conditions possible with such machines. Likewise, the amount of ammonia gas which it is necessary to circulate to produce certain amounts of refrigeration may vary in equally wide ranges.

The engineer who keeps records of costs in the operation of the plant has been compelled to go through a tedious routine of figures to maintain his daily records. This process becomes a burden when the engineer has a number of plants in various parts of the country. These plants must necessarily be operating under widely varying conditions which different climatic conditions make inevitable. To meet these conditions and include the greater number of variables, Charts I and II have been prepared and used by the writer in records covering the operation of a number of refrigerating plants.

Chart I is based on a table in a paper read by Thomas Shipley before the 1906 meeting of the American Society of Refrigerating Engineers. It shows "the mini-

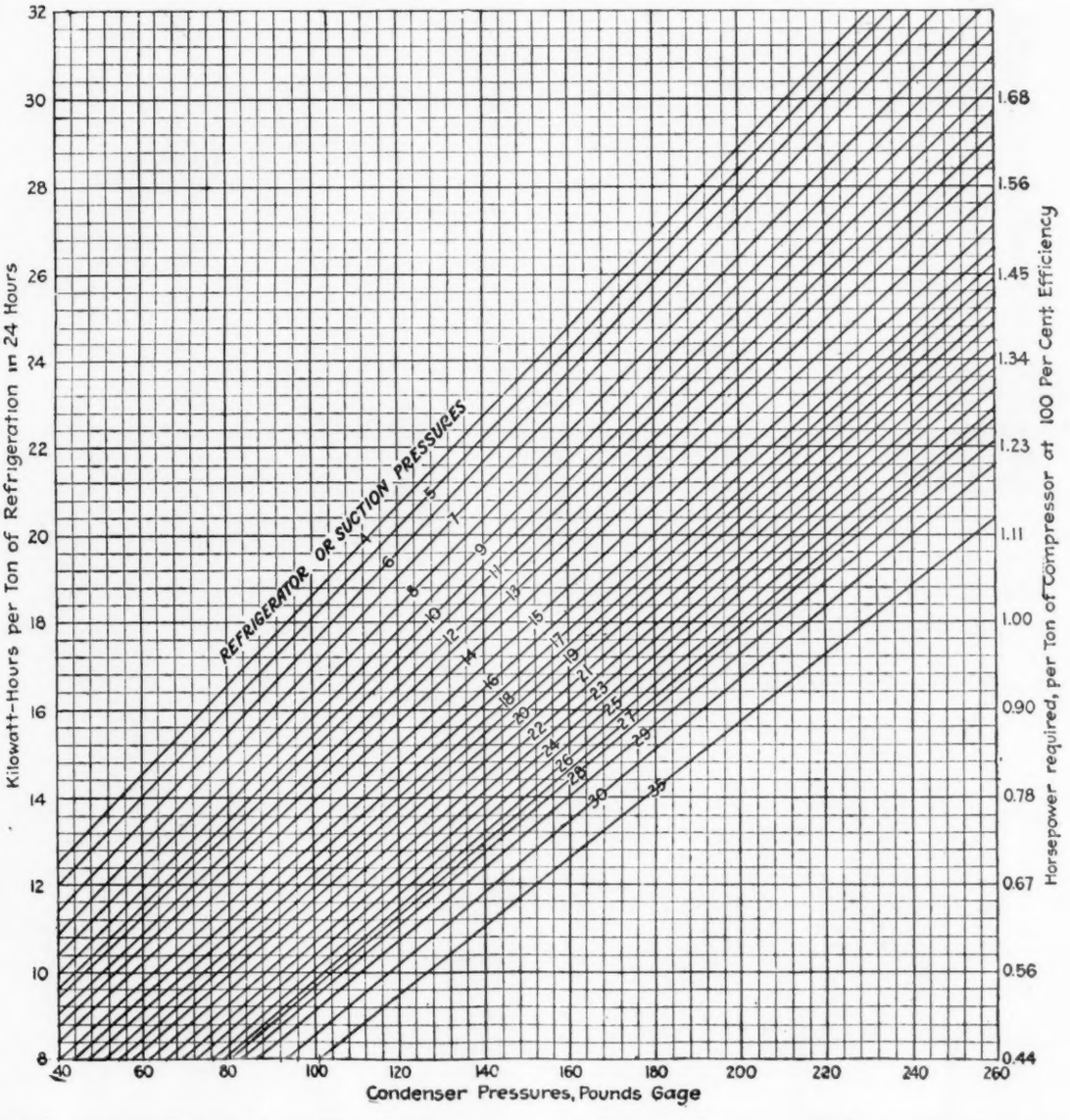


CHART I. POWER REQUIRED PER TON REFRIGERATION FOR VARIOUS SUCTION AND CONDENSER PRESSURES

mum theoretical power utilized in a compressor to compress sufficient ammonia gas which, when liquefied at the pressure stated, will, upon being evaporated from the temperature corresponding to the given pressure to the temperature corresponding to the pressure in the evaporating system, do the same amount of work (have the

same cooling effect) as is done in the melting of one ton of ice." The kilowatt-hours, if the compressor is motor driven, to fulfill above conditions in a twenty-four hour period, is shown on the right, and the horsepower required is given on the left-hand margin. In each case the volumetric efficiency of the compressor and the efficiency of the motor are assumed as 100 per cent.

Chart II is to be used for closely estimating the work of the compressor or the amount of refrigeration produced over any period when the capacity and volumetric efficiency of the compressor are known.

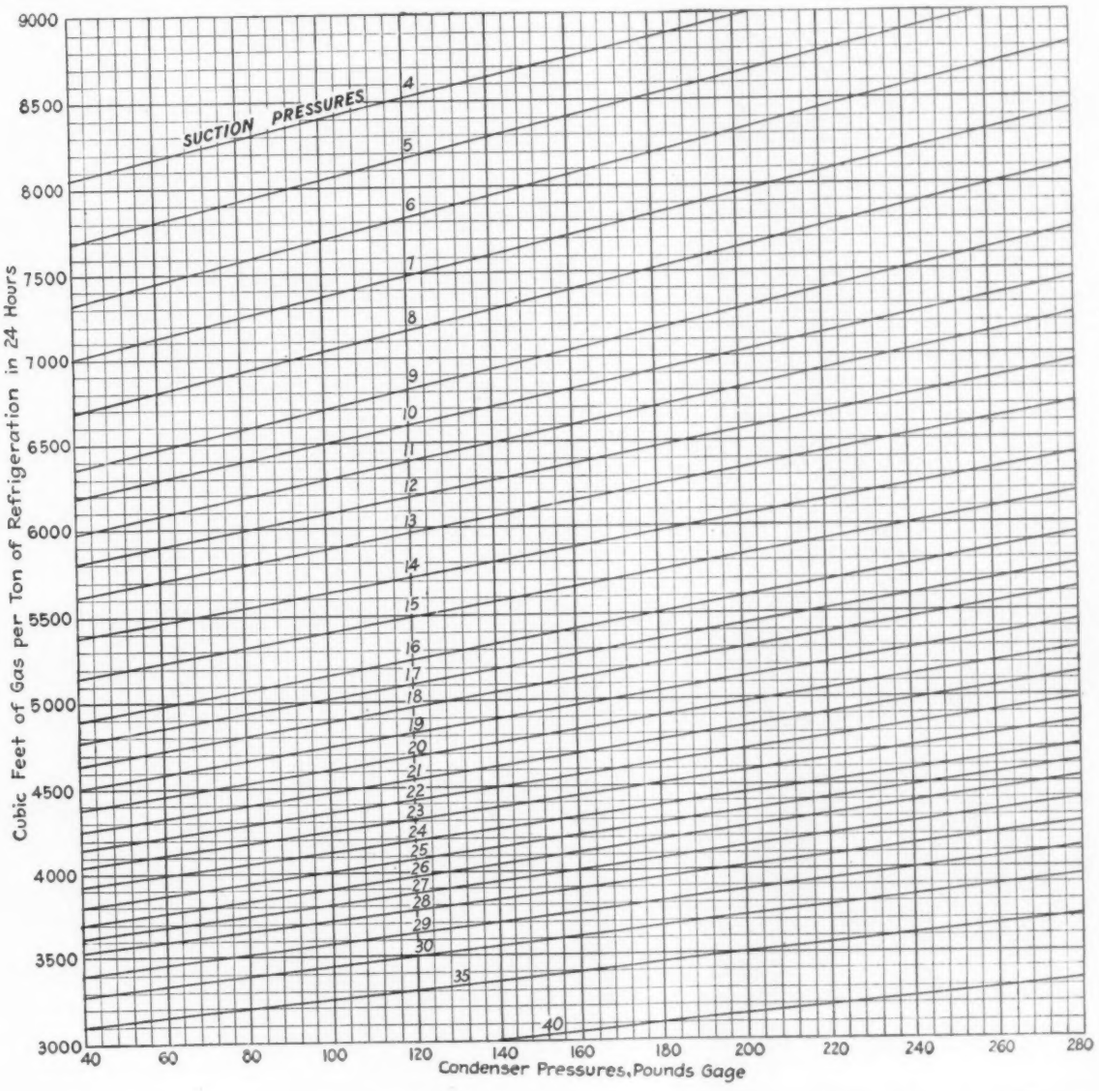


CHART II. VOLUMES OF GAS PER TON REFRIGERATION FOR VARIOUS SUCTION AND CONDENSER PRESSURES

This refrigeration as given is expressed in tons per twenty four hours. In the use of Chart I, take as an example an average condenser pressure of 180 lb. gage, average suction pressure, 16 lb. gage, to find the horsepower of the motor or engine required to drive a 100-ton compressor, also the current consumption on a twenty-four-hour load at the given suction and condenser pressures, follow the line for 180 lb. condenser pressure up, until it meets the 16-lb. suction-pressure line, and then along on the horizontal line to the right for the horsepower to drive and to the left for kilowatt-hours per ton for twenty-four hours. At 100 per cent. compressor efficiency it will require 1.11 hp. per ton of refrigeration. Assuming 80 per cent. volumetric efficiency, then 1.11 divided by 0.80 and 15 per cent. added for friction load, gives nearly 1.6 hp. per ton refrigeration.

To the left it will be found that it requires 20 kw.-hr. per ton refrigeration in twenty-four hours at 100 per cent volumetric efficiency of the compressor. Then 20 divided by 0.80 volumetric efficiency and 15 per cent. added for friction, dividing this figure by 0.90 (approximate motor efficiency) gives 31.94 kw. per ton of refrigeration in twenty-four hours. The total current consumed, 31.94 times 100 (rating of the compressor) gives 3194 kw.-hr.

In the use of Chart II, it is necessary to know the capacity of the compressor over some definite period. If the machine starts and stops frequently or is of the automatic type without attendance, a revolution counter should be attached by which the capacity will be known over any period regardless of frequent stops.

As Chart II gives the number of cubic feet of gas required at 100 per cent. efficiency, it will be necessary to find the actual displacement of the compressor at the operating pressures for the proper period of time or num-

ber of revolutions. It is advisable to bring the displacement of the compressors to the same condition as stated in the chart, or 100 per cent. for a definite time, and thus obtain results by one division or multiplication.

The power required to drive small ammonia compressors of the single-acting type where the condenser pressures are not known but are for average refrigeration will be approximately as follows:

Capacity Tons	Horsepower Required	Capacity Tons	Horsepower Required
1	2	8	14
2	3½	9	15
3	5	10	17
4	7	15	25
5	8½		

In the table a friction load of 15 per cent. has been assumed. This would be the average for medium to large engine-driven units. For smaller units and belt drive the friction load may run greater, although the worst condition is seldom over 20 per cent.

If the ammonia liquid is cooled below the temperature corresponding to the condenser pressure, the tonnage will be increased thereby, but as this is not a usual operating condition it has not been included in the charts. The standard conditions have been assumed in which a ton of refrigeration is equivalent to the circulation of 26.7 lb. of anhydrous ammonia per hour at 15.67 lb. above the atmosphere, condensing pressure taken at 185 lb. gage pressure.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—We visit an uptodate power plant and Hunter discusses high- and low-priced machinery; he points out that cheap units are uneconomical in operation. Some examples of wasteful pumps and fan engines are given as well as the reason for their condition.

The next morning after our visit to Scalp Level I was up and ready for another tramp before Hunter put in an appearance. When we started out for the day, we headed for No. 35 colliery of the Berwind-White Coal Mining Co., at Windber, Penn. Here we found two 100-kw., three-phase, 25-cycle, 6600-volt turbo-generators running at 1500 r.p.m. There was also a cross-compound engine-driven unit, the generator having the same phase, cycles and voltage as the turbine generators. Beside this equipment and the motor- and engine-driven exciter units, there were two 225-hp. motor-generator sets delivering alternating current, Fig. 1. M. J. Gross, the engineer of the plant, told us that the electrical energy was transmitted to eight substations and then transformed to 550 volts direct current for use in the mines. Steam for the plant was generated by twelve 250-hp. water-tube boilers equipped with mechanical stokers.

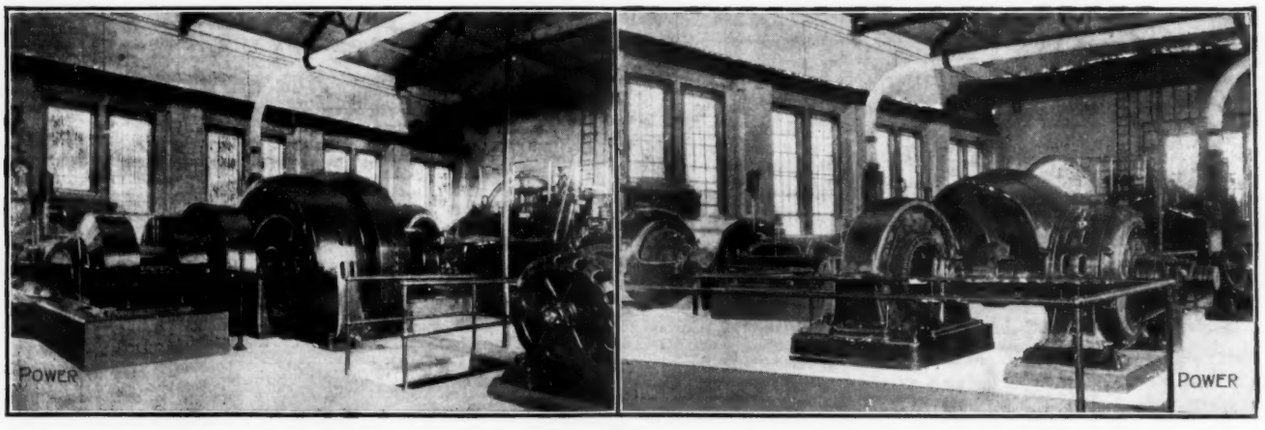


Fig. 1. Power Plant from Which No. 35 Colliery Is Operated

Here was a plant as uptodate as the one we had visited the day before. That both were owned by the one company was a striking indication to me that the central station did not cut much ice with these operators; that they found it economical to generate their energy on the ground where it was to be used.

"How is it that this company has built such substantial power plants while others appear to have been built apparently for short occupancy?" I asked, at the same time yanking Hunter out of the way of an electric locomotive drawing a train of empty coal cars into the mine.

Hunter calmly proceeded to count the cars as they rumbled past—an even hundred, I believe—before he turned to answer my question.

"That is business," said he. "These mines are a long way from a central station in the first place; in the second, it will be a good many years before the mines will be worked out. For these reasons it is advisable to put up a substantial building to house the generating units. If the mines were to give out within the next few years, inexpensive buildings would have been the proper structures to have put up. The machinery, however, should be of the best, for when the present mine workings are abandoned, the machinery can be moved to a new site for further use."

"Well, that's clear enough, but with high-priced machinery the fixed charges will be high, while if the machinery is low in cost they will be correspondingly low."

"Right you are, but don't forget that low-priced machinery makes high operating costs. A cheap engine will generally consume an excessive amount of steam,

which means that an increased boiler capacity must be had over what would be required with an economical engine plant; this, of course, would lower the saving made on the price of the engine.

"My contention is that cheap machinery means high maintenance costs, let alone the losses occasioned by frequent shut-downs.

"When these units were put in," and Hunter motioned toward the power plant, "they were selected, no doubt, after the question of first cost and operating costs had been considered in conjunction with the load that could be expected during the year. The result was a plant containing expensive machinery and reduced fixed charges, low steam consumption, small repair bills and satisfactory operation. The opposite could be expected with low-grade apparatus."

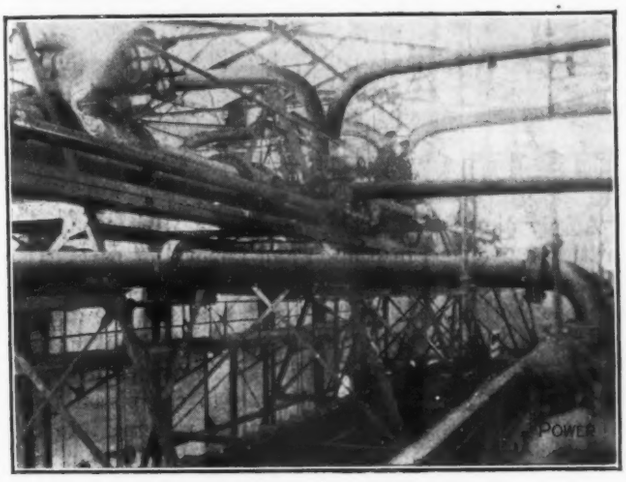


FIG. 2. THE WASTE OF STEAM IN THE AVERAGE MINE PLANT IS DUE LARGELY TO BARE PIPES, LEAKING JOINTS AND WORN ENGINE VALVES AND CYLINDERS

"You would recommend direct-connected units in preference to belted generators, I suppose?"

"I certainly would, because with direct-connected units all troubles from belts slipping, belt repair, etc., are out of the way, less floor area is required, and a smaller building can be used, which means a lower first cost."

"The fact that the general arrangement of the plant is simple, without any attempt at frills, should help with the first cost and with that of maintenance."

"Now you're talking! While simplicity does not mean cutting out necessary apparatus, there is no sense in putting in lines of piping to provide for a breakdown that in practice seldom comes. A steam plant should be designed to avoid as much as possible all chances of breakdowns, and, therefore, the best of material should be used at all points, for one breakdown caused by faulty material will offset the cost of the best many times over. Did you notice how the coal is delivered to the boilers?"

I confessed I had not.

"I'm surprised, because the delivery of coal to a boiler plant is of importance. This arrangement here is about as simple as it can be. Coal fresh from the mine is taken to the boiler house in the mine cars and, after passing through a coal crusher, is delivered to the coal bin above the stoking aisle in the boiler house. Of course, this is an exception, because but few steam plants are situated to take advantage of a drift or a slope level with the boiler-house coal bunkers."

"When you speak of simplicity of design don't you favor cross-connections, so that where several engines have their batteries of boilers they can be arranged to operate with another battery?"

"Now, don't make a mistake; I haven't said any such thing. In fact, interconnections between boilers and engines should be so arranged that any boiler or set of boilers can be used with any engine. The idea is that this arrangement gives the engineer an opportunity to make repairs to any set of engines or boilers without interfering with those in operation.

"With some arrangements of pipe lines there is no certainty that a supply of steam will be had for the fan engines, pumps and hoisting engines in case a boiler tube should burst. One safeguard against the stoppage of the steam supply is to equip each boiler with a nonreturn valve. Then if a tube does fail, putting one boiler out of service, the others will supply enough steam to operate the mine. If an accident serious enough to wreck the boiler plant occurs, then the best protected piping would be of no avail."

"I'll tell you, Hunter, I think the piping between the boilers and engines should be short, and provision made to take care of expansion in all high-pressure steam lines. For the life of me, I can't see how many steam lines could be any shorter than they are, although they may be several hundreds of feet long."

"Unless the mine is equipped with electric drive there is no way to get rid of long pipe lines, and unless properly drained there will be trouble when the water reaches the engines in large quantities, as there is danger of its doing, and wrecking the engine. On the other hand, if the water of condensation gets back into the main line there is danger of bursting the fittings by water-hammer. Not only should the pipe lines be drained, but the valves should be placed so that there will be no pockets of water when the valve is closed."

"The idea is that the pocket of water would go to the engine in a slug when the valve was opened?"

"You've hit it exactly! It is easy to collect such water in traps and return it to the boilers."

During the conversation we had made our way toward a fan house in which was a motor-driven fan. The absence of leaky pipe joints, piston packing and pounding engine was noticeable. Furthermore, the room was clean and free from the mass of grease and general filth so often found.

"This is a good object lesson in favor of electric drive," observed Hunter; "everything neat and clean, no vibrating steam pipes and other annoyances."

"Some steam lines do vibrate; how would you prevent it?"

"Putting in a receiver near the fan engine will frequently stop vibration if the receiver is of sufficient size to supply the engine with steam without materially lowering the pressure in the receiver. This would allow of a practically continuous flow of steam to the engine from the boiler and relieve the pipe of pulsation.

"The waste of steam about the average mine power plant is frightful, due to bare pipes (Fig. 2), leaking valves and worn cylinders. When there are apparently not enough boilers, more are put in; this is generally a waste of time and money. It would be more to the

point to put all the engines and pumps in first-class condition, thus consuming a minimum of steam. Then the existing boiler plant would be sufficient for, if not in excess of, the steaming capacity required."

"You don't seem to have a high opinion of the steam equipment of some mines," I remarked as we left the fan house and started toward the street-car tracks in the town.

"Do you know that there are pumps operating in mines on a 24-hr. run which have been in use thirty or forty years and consuming—well, I wouldn't want to say right out, but 160 lb. of steam per water-horsepower would not be too high a figure.

"What can be expected when a pump is operated for long periods and not shut down until something happens? When repairs are being made, nobody thinks of making the pump run more economically; the one idea is to get it back in service as soon as possible, and but little attention is given to the condition of the cylinders, pistons, valves, etc. It's no wonder that steam is wasted.

"The same neglect is found with fan engines. They run day and night, seven days a week, and there is but little opportunity to overhaul them. I have known of fan engines that used about 80 lb. of steam per indicated horsepower-hour when half of that amount would have been excessive.

"The great trouble is that many mine operators conduct their business with the idea of getting a maximum coal output and pay little, if any, attention to the machinery that makes this output possible."

That afternoon we packed our grips and made for Pottstown, where, we were informed, there were several interesting collieries.

The Diesel Principle Applied to Small Engines

SYNOPSIS—This engine, of German design, is of the high-compression, double-piston type and embodies simplicity as well as compactness. With a direct-connected generator it is made in sizes of 10 to 40 kw.

A successful attempt to adapt the Diesel principle to the small oil engine has been made by the Allgemeine Elektricitäts Gesellschaft, of Berlin, which is now putting out direct-connected generating sets, in the two-cylinder model, with capacities of 10 to 40 kw. The engine is of the double-piston, two-cycle type, employing 420- to 570-lb. compression and a fuel-injection pressure of approximately 850 lb. In order to insure reliability in the hands of unskilled attendants, simplicity, accessibility and interchangeability of parts have been made an important feature in the design, and compactness is further increased by having the end of the crank case terminate in a flange to which is connected the stator of the generator.

Referring to Fig. 7, the compressor is seen to be mounted in line with the working cylinders and is driven from the main crankshaft. It comprises a two-stage injection pump E and a scavenging pump P. The latter is double-acting and is regulated by a rotary slide valve mounted on the vertical intermediate shaft. The upper part of the crank case forms a scavenging air reservoir L, into which project the lower ends of the cylinders. These are provided with scavenging ports, so that the air follows the most direct path. The relative locations of the pump P and the reservoir L do away with the necessity for intermediate piping. The injection pump is fitted with ring plate valves.

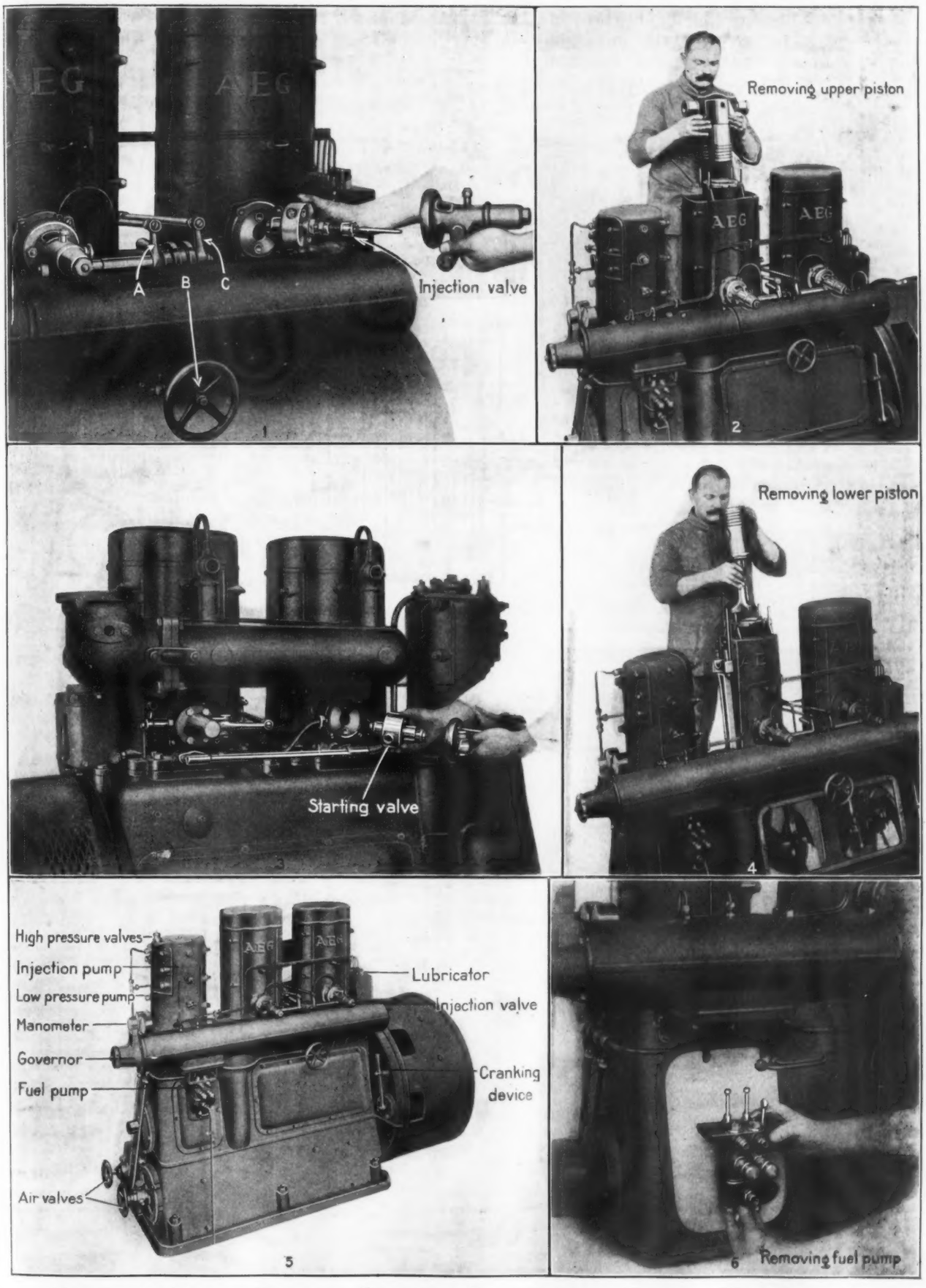
The air for starting and for fuel injection is stored in the cylinder F, located with the lubricating receptacles S in the under-frame of the engine. This not only provides a more convenient arrangement, but also allows the numerous valves for starting and fuel injection to be replaced by a common distributor, which carries a manometer (see Fig. 5) and a safety valve.

Amply dimensioned hand openings are provided, permitting convenient inspection and removal of parts. The driving gear is provided with forced lubrication, the oil being led to the bearings through passages in the casting and then distributed through recesses in the crankshaft to the pivots of the connecting-rods and the suspension rods, finally rising further through pipes to the piston pins. Nonreturn valves prevent the oil from running into the pipes when the engine is at rest, and a hand pump permits the pipes to be filled or washed out while the engine is idle. In the larger sizes the pistons are oil cooled. In this case the oil, which is supplied by a gear pump, flows to the lower pistons through jointed pipes and to the upper pistons through conical pipes, finally discharging through funnels.

A special point has been made of rendering the piston easily demountable. In about 10 minutes after stopping, the upper piston can be removed, and in another 10 minutes the lower piston can be taken out. These operations are shown in Figs. 2 and 4. There are no pipes to be disconnected, no valves to be removed, and no covers, tightened by packing, to be unbolted.

The crankshaft is driven by worm gearing through a vertical intermediate shaft, which can be removed bodily with the bearings and wheels after loosening a few bolts. The governor, mounted at the front end of the camshaft, works directly onto the fuel pump by means of an adjusting rod sliding in a slot on the camshaft. This does away with any external lever transmission. The handwheel shown is for adjusting the speed, which can be read from a tachometer placed above it.

Some difficulty was experienced in designing the fuel pump for the small engine, especially in connection with the regulation of the quantity of fuel, which in many cases amounts to only a few drops. As the same amount of work is done in one cylinder of the new engine as in two cylinders of the single-piston type, however, the quantity of fuel per cylinder is doubled, and its regulation is thus simplified. It is effected by the movement of a cam acting on the suction valve. The starting valves are controlled mechanically by means of cams from the



FIGS. 1 TO 6. SHOWING ENGINE AND GENERATOR COMPLETE AND THE EASE WITH WHICH PARTS MAY BE REMOVED

camshaft. The driving lever *A* (Fig. 1) for the starting valves and the lever for the injection valve are arranged eccentrically, so as to bring them into operation alternately by switching over a lever. For starting, therefore, it suffices to open the air admission by means of the handwheel *B*, and to throw over the hand lever. These starting valves are accessible and can be exchanged in a few minutes. The injection valves for admitting the fuel into the working cylinder are placed opposite the starting valves, and the needle is likewise moved by means of a disk from the same camshaft. If it should prove necessary to repack an injection-valve needle, the entire

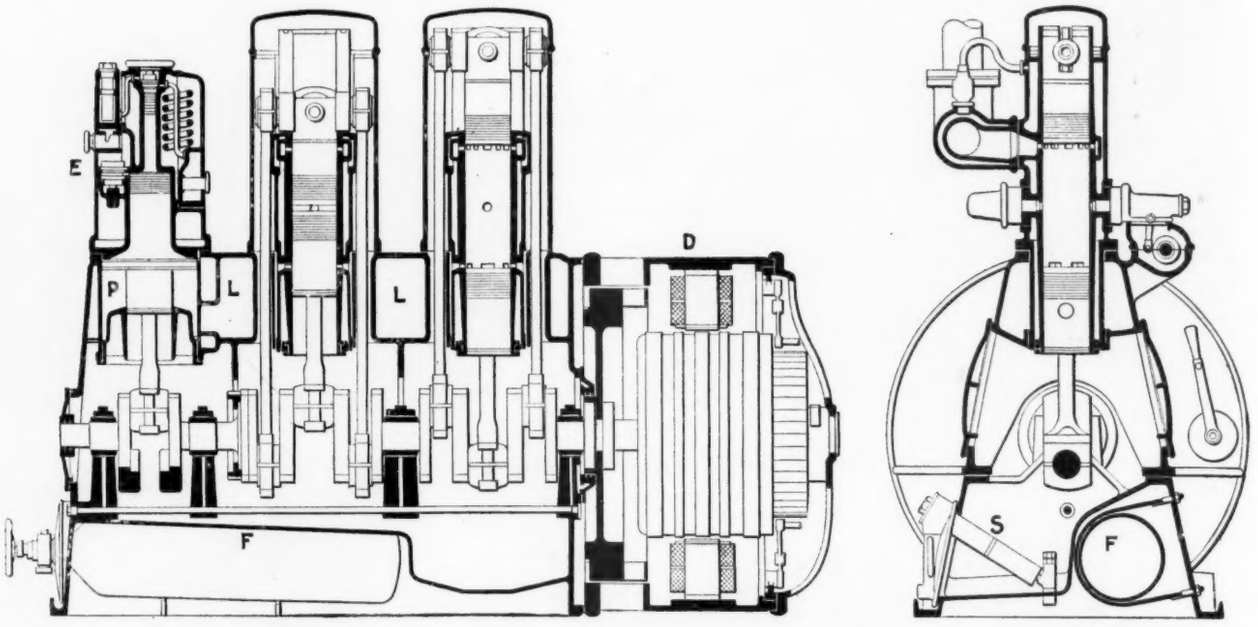


FIG. 7. LONGITUDINAL AND END SECTIONS THROUGH ENGINE

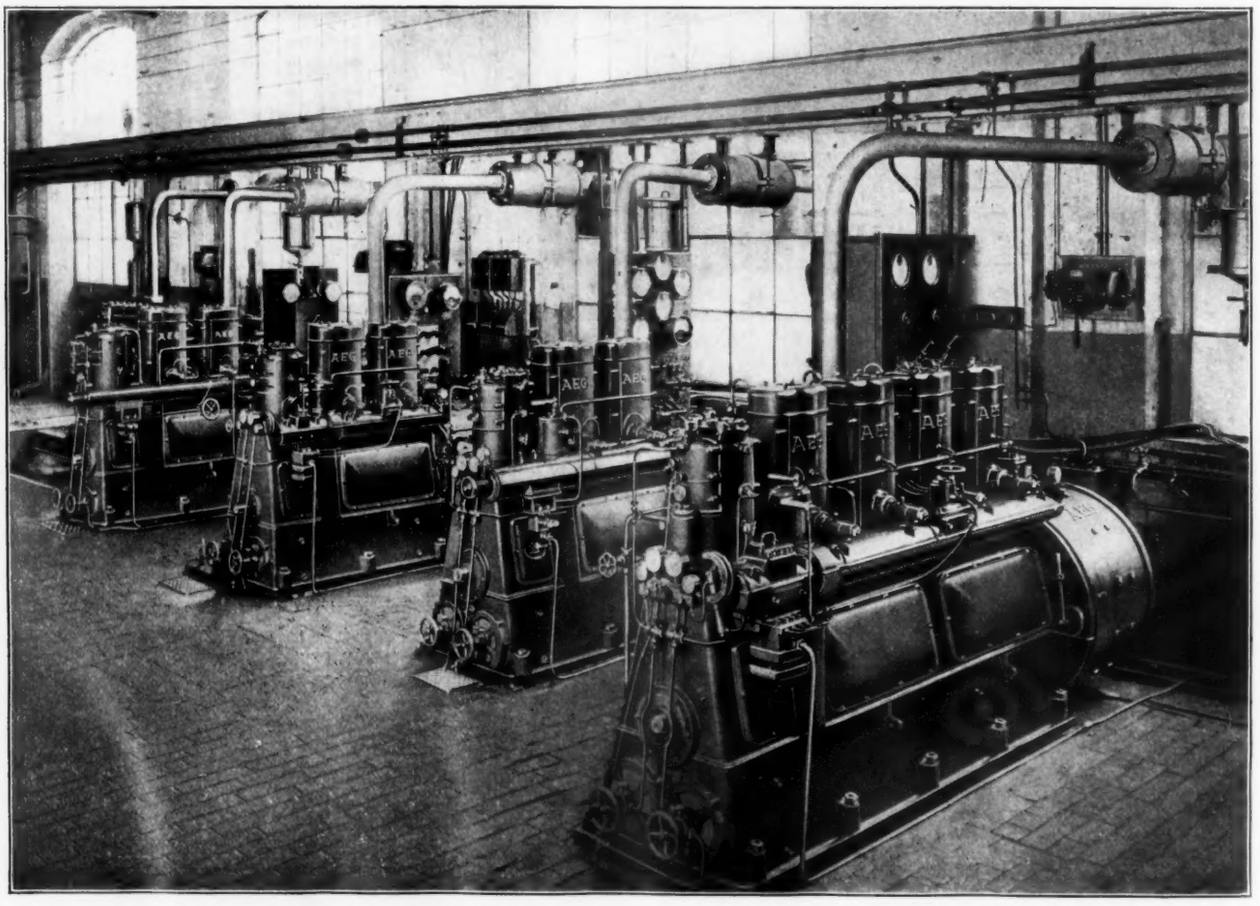


FIG. 8. ENGINES SET UP FOR TESTING AT A. E. G. WORKS

valve can be taken out after the engine has been shut down, and a spare one put in its place; this takes about 15 min. The adjustment of the play between the cams and camshaft and the roller of the driving lever, and therefore the exact timing for the opening of the needle, is carried out by means of calibrated disks placed beneath the needle.

These engines are built for a speed of 500 r.p.m., at which they develop their normal output.

Coal, the Big Item

The largest single item in the operating costs of any steam power plant is coal. In most plants the purchase of coal is a matter of careful consideration, and in the larger ones it is usually bought under specifications. Once the coal is in the bunkers, this careful consideration stops and the actual burning of the coal is very rarely given more than a passing thought, as long as the steam pressure is kept up. Of course, there are some plants where this does not apply, but in the majority it does.

The men employed are paid the lowest possible living wage and are chosen more on the basis of the wages they will work for than the results they are able to produce. The man who burns the coal can easily vary the efficiency of the boiler by 10 to 15 per cent., or the heat absorbed by 15 to 20 per cent., yet he is at the bottom of the payroll.

No revolutionary advancement has been made in power plants recently, and the increased efficiency is accomplished only by taking each process separately and bringing it up to the highest standard. It would therefore seem wise, in attempting to increase the overall efficiency of a plant, to start with the item that represents the largest expenditure and work down the list.

In office-building plants the cost of coal represents some 35 to 40 per cent. of the total expenses and boiler-room labor 12 to 15 per cent. In big plants the cost of coal is 50 to 55 per cent. and the boiler-room labor 7 to 8 per cent. Take a concrete case of a certain office building in New York City that employs two firemen at $600 a year each. Their coal costs approximately $10,000 a year. If we assume that the boiler efficiency is 60 per cent., and that by paying $900 a year men could be obtained who would operate the boilers at an efficiency of 70 per cent., it would be a paying investment. The increase in wages is $600 a year. The increase in boiler efficiency amounts to a reduction in coal burned of 14.3 per cent., or $1430. The net result is $830 to the good by the change—not a matter of philanthropy.

Any plant owner can figure out for himself what a small increase in the boiler efficiency will amount to in dollars and cents, and may find it profitable. The efficiency of the boilers may be increased in several ways, but first, proper equipment must be furnished. Every boiler plant should be equipped with a draft gage, stack thermometer and means for determining the CO_2. The cost of this whole equipment need not exceed $100, which would be repaid in a very short time.

Then the firemen should be taught the use of this apparatus to determine the proper method of handling the fires to secure the highest efficiency. A bonus system for savings over a certain amount would probably be productive of the best results. If the firemen are able to save the plant money by their efforts, they should logically be entitled to a part of it.

Dayton Power Pump

The Dayton Pump & Manufacturing Co., of Dayton, Ohio, is placing on the market a new power-driven

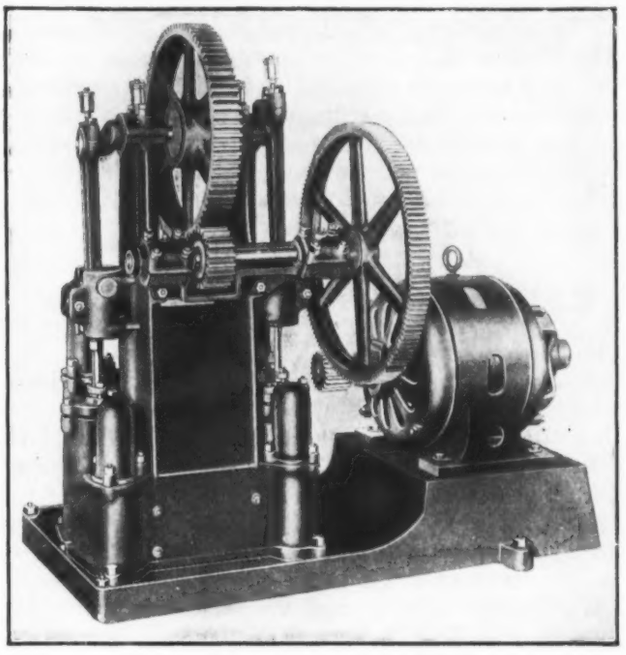


FIG. 1. MOTOR-DRIVEN DUPLEX DOUBLE-ACTING PUMP

pump, Fig. 1, of the duplex double-acting type. Being double acting on both sides, four impulses are imparted for every revolution of the cranks, and a steady stream

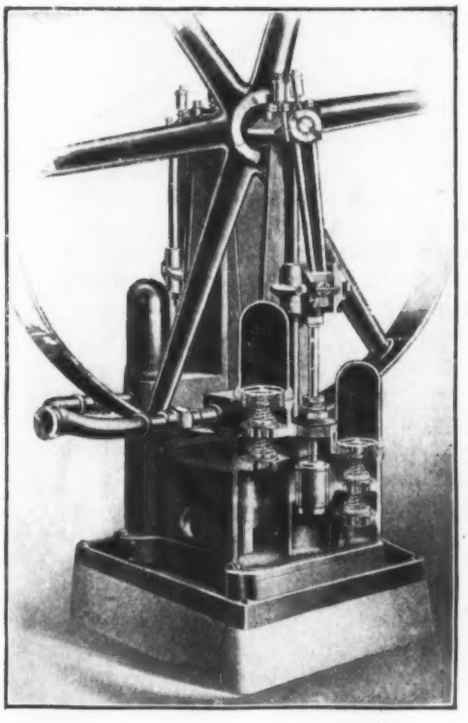


FIG. 2. VIEW EXPOSING VALVE AND PULSATION CHAMBERS

is discharged. The cranks are set at 90 deg., so that when one piston is moving at its highest speed and delivering its greatest amount of water, the other piston is moving at its lowest speed and delivering a proportionately smaller amount of water. In this way the flow and torque are equalized, so that a minimum expenditure of power per cubic foot of displacement results.

An unusual feature is an air chamber over each valve chamber, and in addition, a large air chamber forms part of the body of the pump immediately under the gears. As a result of these five chambers there is no perceptible wave line to the discharge, which is practically as steady as the outflow from a centrifugal pump. The arrangement of plunger and valves is shown in Fig. 2, a sectional view of the pulley-driven pump. The new motor-driven pump is made for pressures up to 100 lb. and is designed primarily for house service.

Chimneys for Havana, Cuba, Power Plant

The accompanying illustration shows the five chimneys constructed by the Weber Chimney Co. for the Havana Railway, Light & Power Co., Havana, Cuba.

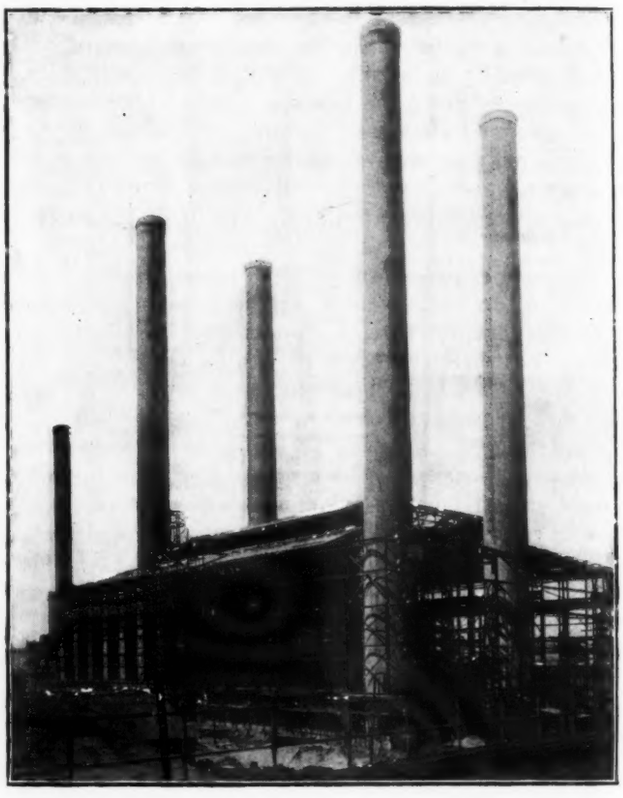
In 1910 the company built a cylindrical chimney 200 ft. high by 10 ft. diameter, of reinforced concrete. After it had been in use approximately three years, a consolidation of the Havana Railway, Light & Power Co. and the Havana Gas Co. necessitated the construction of a large central station, which was started early in 1913. An order was placed for four coniform reinforced-concrete chimneys, each 275 ft. high and 14 ft. inside diameter at the top. Six months from the date of starting work these were completed.

The chimneys rest on individual foundations 32 ft. square and 6 ft. 6 in. thick, supported by piles. In the lower part of the foundation are four layers of steel. The bottom layers run diagonally to the sides and consist of ¾-in. round bars at 8-in. centers; the two upper layers are placed from 4 to 6 in. above the diagonal net and about 8 in. from the bottom of the foundation, and run parallel to the sides. The vertical bars in the shaft run into, and anchor beneath, the horizontal steel reinforcement in the foundation, providing anchorage for the chimney shaft.

The outside diameter at the base of the shaft of each chimney is 20 ft. 6½ in., tapering to an outside diameter of 15 ft. at the top. The wall thickness of the shaft at the foundation is 19 in., tapering to 6 in. at the top. There are two hundred ¾-in. round vertical bars in the shaft, extending to a height of 22 ft. above the top of the foundation, where the number is reduced to 132 for the next 20-ft. section, decreasing uniformly to the top, where there are sixteen ⅝-in. round vertical bars in the upper 30 ft. of the chimneys. The smoke openings (7 ft. 2 in. wide by 14 ft. 2 in. high) which received the breeching from the boilers are 56 ft. above the foundation and are 20 per cent. larger than the area of the chimney at the top. There are two opposite openings in each chimney, and a baffle wall is built in the center of the chimney, starting 2 ft. below the bottom of the openings and extending to a point 3 ft. above the top.

There is a reinforced-concrete lining 58 ft. 6 in. high, starting at a point 4 ft. below the opening. The lining is reinforced vertically and horizontally by sixteen ½-in. round vertical bars, evenly spaced, and by horizontal rings at 14-in. centers encircling the vertical members; these take up the shearing stresses caused by the wind and temperature. The lining is carried on a corbel supported by the outer wall of the chimney. All vertical steel in the shaft is calculated to take up stresses produced by a wind velocity of 100 miles per hour.

The chimneys are inside of the power house, and in order to utilize the space two storage rooms were provided in each. A floor was placed at an elevation of 18 ft. above the foundation, and an opening provided so that this part of the chimney is accessible. At 36 ft. above the foundation is another floor and storage room. A ladder is provided on each chimney, running from the top of the chimney to the roof of the building.



REINFORCED-CONCRETE CHIMNEYS FOR THE HAVANA POWER PLANT

The present boiler installation consists of 24 water-tube boilers, rated at 650 hp. each, a total of 15,600 hp.; provision has been made for eight additional stoker-fired boilers. Three turbine generators of 10,000 kw. are operating at present, with provision for an additional unit.

The Action of Ice and Common Salt (sodium chloride) is to lower the mixture temperature below 32 deg. The depression of temperature depends mainly on the proportion of salt used, and partly on the rate at which heat is supplied from the outside. The following table gives the approximate temperatures resulting from the use of different proportions of salt and ice:

Per Cent. of Salt in Mixture	Temp. of Mixture, Deg. F.
5	26.6
10	19.9
15	11.8
20	1.6

The minimum temperature obtainable with ice and salt is about —7.5 deg. F., this temperature being given by a 24 per cent. mixture.

Editorials

Fuel Economics

The slogan, "Made in America," is aimed to incite domestic industries and manufactures. As a result many new factories will be built in the near future and probably many old plants will be remodeled to meet increased demands and manufacture new lines. All of these factories will require power, which will benefit the central stations and also be the occasion for many new isolated plants—some large and some small. To manufacture economically, cheap power will be required, will be absolutely necessary, and though the "Made in America" indorsement may secure many sales at this time, when serious foreign competition is not felt, the time will come when only the American producer who is manufacturing economically and efficiently will be able to hold his own.

Even in an efficiently operated plant, from twelve and one-half to fifty per cent. of the cost of power is found in the coal bill, the large power house operating on the lower unit cost. Coal bills must then be kept down, and to do this only the economical coal must be burned, the coal that will evaporate the most water for a given outlay. This does not mean the best coal procurable nor yet the cheapest; it means the most economical, for efficiency in combustion is almost entirely a matter of correct grate and combustion-chamber design and care in firing, conditions that may be relatively realized with the same results when using a low-grade coal as when using the more easily consumed coals of high heating value.

The price of coal varies to a great extent in different localities, and coals vary among themselves in heating value and in ash and refuse contents. The heat units in the coal increase its value but not proportionately, for the ash and refuse contents not only add expense by entailing definite outlays for their disposal, but also have the tendency to reduce boiler efficiencies. Of two grades of coal of equal heating value, the one with the lower proportion of ash and refuse will develop the greater boiler efficiency—grates and combustion chambers being equally well proportioned for their respective grades of coal and equally good attention paid to the firing of the boiler. The detracting effect of increased ash and refuse contents of a coal is not as great ordinarily as the beneficial effect of an increase in heating value of the fuel, the diluents forming but a comparatively small proportion of the coal, unless it happens to be a very inferior grade. Heat units per pound generally govern the price of the coal, but the price in no way fixes its true economic value, for the increase in cost of high-grade coals is much more rapid than the increase in their heating value.

As a general rule, where coal is relatively cheap—near the source of supply, for instance—more heat units are purchased for the dollar when buying a low-grade coal. Where coals are expensive, on the other hand, the heat units sold for a dollar are more nearly the same for coals of various grades, as in such localities the coal has to carry a burden of freight and delivery charges that are not proportioned to its heating value but are unduly severe on the poorer coals, notwithstanding that freight rates are usually somewhat lower on poor fuels. Where coals are cheap, the most economical grade to use is the poorest grade that can be efficiently burned on properly proportioned grates, etc.; while in sections of the country where coals command high prices, better grades can be economically used.

With the constantly increasing price of coals, one other general rule tends toward economical choice of fuel for an efficient power house, which is that in cases where two grades of coal do not vary greatly in economic value—fuel cost per boiler horsepower—it is usually advisable to adopt the poorer grade even when the net fuel cost is slightly greater than that of the higher-grade coal. The fuel cost of the more economical and higher-grade coal increases more rapidly for an increase in tonnage cost of fuel than is true in the case of the poorer coal, so that only a little of the inevitable increase in the price of all coals will throw the economic balance in favor of the inferior coal and any further general increase in cost of coals will steadily increase the relative economy of the fuel of less heating value—the saving increasing progressively.

The Archaic Boiler Horsepower

We are glad to see our friends of *The Locomotive* place the stamp of disapproval on the horsepower as a unit of boiler capacity (see page 175). In 1876 a committee of eminent engineers appointed to conduct a competitive test of the boilers at the Centennial Exposition decided upon the rate of evaporation of 30 pounds per hour from feed water of 100 degrees Fahrenheit and at 70 pounds gage pressure (barometer unknown) as equivalent to one horsepower, this being considered about the rate at which a boiler would have to steam per horsepower developed by the average engine of that time, under average conditions.

At the time and at the best it was only the crudest kind of an attempt to correlate the capacity of the boiler and that of the engine, for there were then many engines which required less than 30 pounds of steam per hour per horsepower. Today, with boilers evaporating two or four times as much water per square foot of heating surface and engines requiring only one-half as much steam per horsepower, there is a wide and variable discrepancy between the horsepower of the boiler as determined by the Centennial standard and that of the engine or turbine which it can supply with steam.

How should boilers be bought, sold, and classified—by the amount of steam which they can make per unit of time, or by the number of square feet of heating surface which they contain, or how? The horsepower rating is supposed to be a statement of the rate at which the boiler can make steam, but is in the awkward unit of 34.5 pounds per hour at the standard condition of "from and at 212 degrees." If one wants a boiler which will make

the equivalent of 3000 pounds of steam per hour from and at 212 degrees, he says: "3000 ÷ 34.5 = 90, about. Give me a 100-horsepower boiler."

And then the boiler maker says: "Ten square feet per horsepower—give him 1000 square feet of heating surface." So the thing gets down to a heating-surface basis after all, notwithstanding the fact that the evaporation per square foot of heating surface may vary from 2 to 10 pounds, according to the amount of grate surface supplied with it and the rate at which the coal is burned.

Another basis for rating is the amount of heat which the boiler can absorb per hour. To evaporate 34.5 pounds of water from and at 212 degrees requires 34.5 × 970.4 = 33,478.8 B.t.u. A kilowatt is equivalent to, say 3415 such units per hour. Messrs. H. G. Stott and Haylett O'Neill suggest that the capacity to absorb 34,150 B.t.u. per hour be taken as the unit of boiler capacity, and that this unit be called a "myriawatt," signifying 10,000 watts.

We do not see that this improves matters much. There is no such definite relation between the kilowatt and the number of pounds of steam that it takes to make one, as to warrant the use of an awkward five-place divisor, and it simply means tricking out the old boiler-horsepower in a new regalia of metric trappings and continuing it upon the stage.

Should we "get the hook" for it? If so, when we are describing a plant with four 300-horsepower boilers, shall we say "four boilers of 3000 square feet of heating surface each," "four boilers capable of evaporating 9000 pounds of water per hour each"—or what?

The Practical Man's Boiler Test

Two methods of conducting boiler tests are now generally accepted—one according to the short code of the A. S. M. E. and the other based on the more elaborate standard code. The first contains about forty items, readings or calculations for which are necessary, and the complete code contains over one hundred. Condensed and standardized as are the calculations and complete as is the information gained by following these codes, a boiler test is not simple, but requires considerable preparation and care and consumes much time. Furthermore, when accomplished, the test is rarely typical of actual operating conditions. As a means of establishing a record, or standard, to be striven for by the operating force it is exceedingly valuable, but as a reliable record of efficiency of average operation and a true gage of the economy of the plant, it leaves much to be desired. What is required is a continuous record to show the true efficiency of the plant at all times, a "practical man's boiler test," and a test that the boiler operators can easily comprehend—a test with the results continually before the fireman.

It is neither fair to the boiler-room force nor conducive to the best results to blame it for wastes after they have occurred—especially after they have been going on for some time. The time to call attention to them is while they are occurring. The boilermen should know the instant that the boilers commence falling below requirements, and this can be realized only when simple and continuous records are provided for their frequent inspection.

The apparatus required is neither very complicated nor complex. All that is needed are some automatic device for recording the amount of water fed to the boiler and means of weighing the coal as fired. Automatic firing simplifies the keeping of records of fuel consumed, but even when hand firing is employed, satisfactory records can be kept by weighing the fuel—practice will soon enable a competent fireman to accurately gage his fuel consumption in reference to his boiler feed. Pounds of water evaporated per pound of fuel is all that really matters, and the greater this ratio the better the boiler efficiency. Automatically recording pyrometers, CO_2 recorders and temperature records of feed, etc., all assist in discovering the reasons for falling off of boiler efficiency, but the vital records are those of fuel consumed and water evaporated while maintaining steam pressure.

Careful boiler tests should be made from time to time, but more to fix the standard of operation for the boilermen than for any other reason. The "practical man's boiler test" should be a continuous operation in any boiler plant making claim to efficient operation. It alone can lead to economic operation, it alone is fair to the boilerman, and it alone shows whether the fires are kept in good condition and how carefully and systematically the heating surfaces are freed from soot, etc.

The Loafing (?) Engineer

When we say "loafing," we have in mind the man whom the employer generally finds sitting in the old easy-chair reading a technical or trade journal or just smoking his pipe. Of course, everything is clean about the plant and the machinery is running smoothly, but there can sometimes be detected in the employer's face a look of dissatisfaction. He is paying his engineer a good salary and cannot see that the latter is doing any work and seems to think that he is not getting value received for his money, for a cheaper man could hold down the "Old Armchair" just as well.

This is a view taken by a great many employers and is altogether wrong. The very fact that the engineer finds time to "loaf" and that the owner is not annoyed by frequent shutdowns should be sufficient to convince him that the engineer is a good man and has his department in perfect order. Look out for the engineer that is constantly rushing wildly about with greasy clothes and smutty face and a handful of tools, for unless his plant is dying of old age, there is something wrong with the man.

The employer who wants a man to build boxes, mow the lawn, look after the roofs and a few other "little things" to keep busy, is not looking for an engineer and will seldom get one, and when something unforeseen and real annoying, like a wrecked engine or bagged boilers, happens, he generally gets about as much sympathy as he deserves.

"Some Original Ideas"

When we called for accounts of stupidity, in our issue before the last, under the heading, "Just for Fun," we started something, for we have had a deluge of them. Evidently, nearly everyone has a stock of such stories up his sleeve. We can use but a few of the best, as we said, but if our readers do not mind sending them in, in spite of a long chance that they may not be printed, we do not mind reading them over to see if they are available.

Correspondence

Live-Steam Ash Ejector

In the issue of Dec. 22, page 889, E. H. Clark asks what the trouble is with the ash ejector. I believe if he will increase his steam line to 1½ or 2 in., and then, instead of a bell nozzle, use a throttling nozzle having a diameter not over ⅝ in., he will have no further trouble with the construction as shown in the illustration referred to.

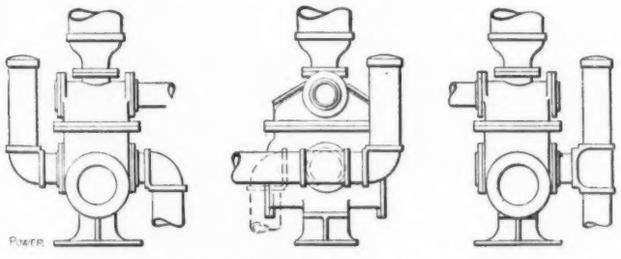
The nozzle should be about even with the back edge of the hopper opening. The ejector will probably work a little better if the end of the 6-in. pipe is left open where the live-steam pipe enters. If closed at all, the area should equal an opening 3½ or 4 in. diameter.

F. F. JORGENSON.

Gillespie, Ill.

Pumping Hot Water

It is surprising how many have trouble when trying to pump water at 210 deg. F. or over. To do this successfully, the pump should be able to deliver the maximum quantity of water at slow speed and the water-supply should be at least 30 in. over the discharge valves, for the reason that if a vacuum is created in the suction pipe, some of the water will flash into steam and fill the water



FORMS OF AIR CHAMBERS FOR SUCTION PIPES

cylinder with vapor. Although it takes 212 deg. F. to boil water under atmospheric pressure, or 14.7 pounds, in a vacuum it will boil at a much lower temperature.

It is a good idea to place an air chamber in the suction pipe, as shown in the illustration. The discharge air chamber should be kept three-quarters filled with air; a glass gage will show the water level at a glance. Should the air get away, the chamber can be recharged by admitting air into the suction line.

A sight-feed lubricator should be connected to the steam pipe above the throttle valve, but a mechanical lubricator may be connected below the throttle valve if desired. If an automatic governor valve is used it should be placed above the throttle valve, but a chronometer governor valve should be placed below the throttle and the oil should pass through them in either case.

It pays to use good packing, which should be soaked in warm water before being put in the piston; the joints should not be in line or the packing follower-bound. It is unnecessary to subject the rod packing to great pressure; it is better to repack than to continue to tighten the gland. It will be found with these precautions that hot water is no more difficult to pump than cold.

THOMAS J. ROGERS.

Jersey City, N. J.

Proper Location of Overflow

In a vacuum steam-heating system that requires no jet water at the vacuum pump, the air-separating tank should not be equipped with such auxiliary appliances as a float-controlled inlet and outlet valve, gage-glass, overflow pipe and handhole. A large tank, with these appliances, is necessary only where jet water is used, because the operator may use more jet water than is required for boiler feed, causing it to flow through the heater into the sewer. This would tax the heater beyond its proper capacity and reduce the temperature of the boiler feed. Therefore, an automatic valve is placed between the tank and heater, so that the tank will overflow to the sewer and not flood the heater when excessive jet water is used.

T. W. REYNOLDS.

New York City.

Concrete as a Furnace Lining*

Our experience with concrete as a furnace lining with underfeed stokers was not satisfactory. The concrete was made of cement and gravel which ranged in size from sharp sand to pebbles the size of a hen's egg in proportions of about 1:4. The old firebrick side walls were taken out, the walls cleaned and thoroughly wet, the concrete was poured in place in forms, in the usual manner, and allowed to dry several weeks before the boiler was put into service. As a means of comparison, another furnace was relined with firebrick at the same time. These furnaces are subjected to hard service, and the clinkers stick to the side walls so that it is necessary to use a sledge and chisel bar to remove them, and more damage is done in this way than by the fire. The concrete walls did not stand as well as the firebrick and the clinkers gave about the same amount of trouble.

Concrete has one important advantage, however, in that it is less expensive to put in, but even if allowed to become thoroughly dry, and heated up slowly, it will give some trouble from cracking and falling out, although this may be prevented by reinforcing it with expanded metal or rods. In our case it was tied in one place only, and perhaps more experience would have produced better results. Oyster shells used as a flux prevented clinkers sticking to the walls to a great extent. Two or three scoops of these shells were thrown in next to the walls on each side after cleaning the fire. I believe that it was the lime in these shells that did the work, and crushed limestone would probably do the same.

*See also page 840, Dec. 15, 1914; page 62, Jan. 12, 1915, and page 131, Jan. 26, 1915.

I find that there is a great difference in firebrick and fireclay, and also in the workmen that build the walls. It is customary in our plant to have this work done by contract, with a guarantee that the work will last one year. One contractor had to rebuild his walls twice during the year, and another put in a wall that was not tied to the outside wall, and it fell out in less than a month. A third put in a wall that did not require any repairs during the year. Good material should be used, and it is essential that it be tied solidly to the outer wall at every fifth course by a header tied into the outside wall, and if subjected to hard usage the headers should be placed every third or fourth course. The fireclay should be made very thin and the least possible amount used. The brick should be dipped in it and rubbed to a tight fit to make a firm bed, so that there is no chance for the mortar to chink out and let the brick fall down. In arches the proper wedge and skew brick should be used to get the proper arc with a full bearing the entire length of the brick without resorting to fireclay to do it.

J. C. Hawkins.

Hyattsville, Md.

Safety in Handling Refrigerants

An editorial in the Dec. 15 issue comments on New York City's refrigerant regulations. The regulations appear in the same issue as does comment on them by members of the American Society of Refrigerating Engineers.

There should be, as the editorial points out, widely adopted rules for the safe operation of refrigeration machines, as there are for boilers and steam-driven machinery. In this city (Chicago) the laws governing steam apparatus are strict, but nothing is said of high-pressure gases or air.

As the water here is exceptionally good for making raw water ice, there are many motor-driven ice machines, and some of them are operated by men who are not licensed engineers. For the heating system in such plants low-pressure steam or hot water can be used, so that the board of examining engineers has as yet nothing to do with them. Surely there is danger in these motor-driven ice plants even though there are no high-pressure steam boilers. Such plants are often located in thickly settled residential neighborhoods, close to schools and churches.

The license law should cover all apparatus carrying pressure, whether steam, gas or air. Regular inspection should be made and none but competent men allowed to operate. There is without doubt less chance of dangerously high condenser pressure with a motor-driven unit than with steam drive. Increased pressure will cause the circuit-breaker to trip or a fuse to blow, whereas a steam engine will keep going until something gives way. But again, circuit-breakers may be tampered with or even blocked in and heavy fuses used by some who do not realize the danger.

Pop safety valves are good in some ways, but sometimes they are both a nuisance and a danger. It is, as Mr. Fairbanks remarked (Dec. 15 issue, p. 866), almost impossible to get an ammonia safety valve that does not leak. When once it opens it seldom seats tight again until it has been taken apart and cleaned of the grayish powdery sediment which has collected. Rather than shut a compressor down in a rush season, many engineers will plug the valve so as not to lose the ammonia.

If the outlet of the safety valve is piped into the suction side of the compressor, it might leak a little all the time and so cut down the efficiency of the machine. Again, if the outlet is piped into water or to a high point above the building, there can easily be a constant loss of ammonia. In one plant the safety-valve outlets of a number of ammonia compressors were piped into a header, and this extended high above the building. The continual loss of ammonia was finally traced to this manner of connection, and the header was done away with and the valves allowed to discharge into the engine room. This often proved a source of annoyance when starting up a compressor which had been down so long that liquid had collected in the discharge line. The valves nearly always opened until the discharge line had become cleared of liquid. In the case of a large direct-expansion system, when a small slug of liquid was pulled into the compressors the valves would often open. In another plant two different suction pressures were carried on several compressors. When one compressor could be spared from the high back pressure, it would be changed over to the low, and often while this change was being made there was loss of ammonia and inconvenience to the men owing to the pop valves opening.

In the foregoing cases the safety valves were a nuisance and were really not necessary. Whether or not a pop valve is the proper thing on an ammonia compressor is a question hard to decide. These valves will relieve a compressor or condenser of over-pressure, it is true, but most engineers will know of the increasing pressure without having the engine room filled with suffocating gas or losing much ammonia. The sound of the machine, whether motor or steam driven, will be warning enough to any competent man. An engineer should be near enough to hear his machinery, or if he should have to go away he should have a man in the engine room who knows enough to shut down in case of accident.

There are not many things liable to happen that will cause a sudden rise in the condenser pressure. Shutting off the water from the ammonia condenser will not cause so sudden an increase of pressure that there is not plenty of time to slow down or stop the compressor.

Any cross-connection between a hot and cold water-supply should not be allowed on pumps supplying a condenser with water. Such a connection can and has caused trouble, but with proper inspectors such cases would be few. Another cause could be the breaking of the suction line. This would allow the compressor to draw in much air, but with an operator within hearing distance he would have plenty of time to shut down. One other cause of dangerous pressure—and in this case I do not believe a safety valve would do much good—is the sudden closing of a valve on the discharge line between the compressor and condenser. This can hardly happen unless an angle or globe valve had been put in the discharge line with the pressure side of the disk toward the condenser. In that case the disk might come off and suddenly close the discharge; the shock would rupture something. But as in other cases proper inspection would minimize the chance of such a condition.

If a safety valve opened directly into a small engine room, the charge of ammonia would probably be lost as it would be impossible for a man to shut down the machine

unless provided with a helmet. A positive device for shutting down the compressor when the discharge pressure reaches a predetermined point is safer. Such devices are in use in some places and work well. Each has a connection from the discharge line to the engine governor, and when the pressure goes to the point at which this control is set the governor acts and the engine is shut down as if the governor belt broke. Such a device can be tried daily or weekly and kept in proper working condition. A safety valve on an ammonia line or container cannot be tried occasionally like one on a steam boiler, to guard against its sticking when needed.

Proper check valves should be placed in both suction and discharge lines of compressors so that in case of a bursting cylinder the gas will be shut off. It is seldom that a serious accident occurs from over-pressure during the operation of an ammonia compressor. When the pressure gets too high it will blow out a gasket in the system or perhaps split a pipe in the condenser. What really causes serious accidents is the dropping of a broken suction valve into the cylinder or something breaking on the piston which will knock out a compressor head. Fortunately, this does not happen often.

Internal explosion in the discharge receivers and the oil separators occurs from permanent gases or inferior lubricating oil which becomes ignited when a high discharge temperature is maintained. The proper oil and care in keeping noncondensable gases out of the system and a correct discharge temperature will do away with the possibility of such explosions.

It is common practice in most new installations to test the high-pressure side with air at 300 lb. and the low-pressure with 150 lb. air pressure, and once a year in old plants after the winter overhauling. This is particularly dangerous in motor-driven compressors where the speed is constant. The air discharged by the compressor reaches a dangerous temperature when the gases from the oil and ammonia mix with it. As several bad ruptures have resulted from this cause, the use of a small unit built for testing purposes should be insisted on and the temperature of the system kept low to insure safety.

Another noticeable neglect in the ammonia system is the lack of suitable hangers for coils and pipe work. In direct-expansion systems the coils on the walls and ceilings of some rooms become so heavy with frost that the hangers give way and allow the coils to fall and break. This can also happen on suction lines not covered and allowed to accumulate frost. There should be proper means of supporting all coils and lines, and care should be taken for the regular removal of frost.

Electrically operated valves are valuable in most plants. In case of accident the machines could be shut down and the ammonia cut off from a point outside the building by means of switches. Discharging ammonia into water or into the atmosphere in case of accident has its dangers in a large plant unless there is a river or lake nearby. Some other way of disposing of a large charge of ammonia must be found.

The adoption by the City of New York of a set of rules for the safe operation and proper inspection of all machinery handling high pressure should be and most likely will be the beginning of improvements in the ice-machine business. Competent men to operate and inspect the plants would make them safe.

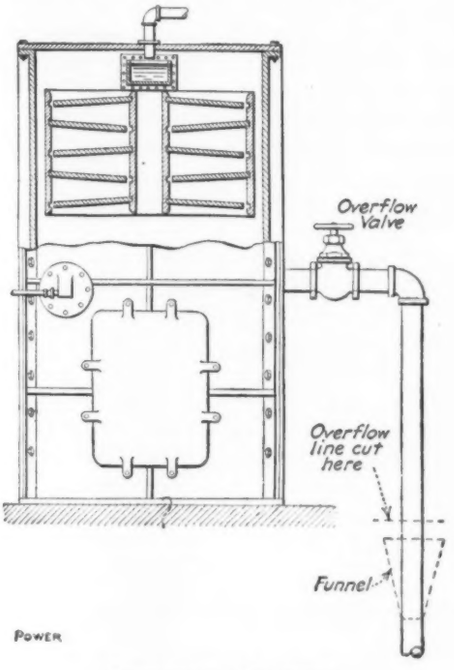
Chicago, Ill. A. G. Solomon.

Saving in the Pump Room

The idea that the greatest possibilities for improvement in economy are to be found in the boiler room seems to be generally accepted. This story, however, is to show that leaks of some magnitude may be found in the pump room.

On taking charge of the plant, the new chief had certain suspicions as to the cause of the low feed-water temperature. As soon as possible he placed a recording thermometer in the feed line. The first chart confirmed his suspicions and an investigation disclosed several interesting items. The feed-water heater was of the open type, to which condensate from various heaters, driers, etc., was returned.

The overflow pipe was connected without an opening and concealed the excessive waste of water. The new chief cut the pipe and put in a funnel (shown by dotted lines in the illustration) and it was observed that for a time a stream of hot water would pour from the overflow—then the makeup valve would open wide. It was evident that water was coming back in slugs, showing that the receiver capacity of the heater was not sufficient for these conditions. Much hot water was being wasted to the sewer at times and a large quantity of cold makeup water was called for at others.



Overflow Changed

More capacity was at hand in the shape of an old receiver, which had been used up to the time the heater was put in. It was still connected up for an emergency so that it was only necessary to combine the two and maintain a constant level in the heater and waste no hot water through the overflow.

The makeup valve was moved from the heater to the receiver and set to operate only when that vessel was nearly empty. At first it was needed, but now it has almost gone out of use. The main bearings of the big engine were water-cooled. This water had formerly been wasted to the sump pit and then lifted to the drain by an ejector. The chief piped this, together with the jacket

water, from the air compressor to the receiver. This nearly equals the amount of makeup water needed.

The average temperature from a week's charts among the first was 140 deg., and from the latest it was 212 deg. These two sets were turned over to the manager, together with a statement of the monthly coal bill. Where the coal formerly cost in excess of $3000, there was now a saving of about $200. As a saving it interested the manager and he actually offered the chief words of praise—but nothing more.

WILLIAM E. DIXON.

Cambridge, Mass.

Separator Drain as Steam Supply to Pump

I read in POWER, Dec. 22, page 890, of using a steam-separator drain as a supply line for a pump. This is very good as regards the engine, but how about the pump?

I think a much better way would be to repair the trap or install one that would work, rather than run this wet steam to the pump, for if only one pump is on the line, and that is shut down while the engine is running, all the condensation must go through the engine. As water is bad for an engine cylinder, as every engineer knows, will it not do damage to the pump also? The pump is one type of engine.

I have seen plants where every precaution was taken to insure dry steam for the engines, yet all the steam for auxiliaries was taken from the lowest point in the steam main without a separator. There was much complaint about the amount of oil required by these pumps. A pump is a wasteful thing at best, and I cannot see where there is any economy in supplying it with wet steam. If there is some good reason for this I would be glad to learn of it.

EDWARD HORSFELD.

New Brighton, Penn.

Who Gets the Promotion?

The Foreword in the issue of Dec. 15 is indeed a problem if sentiment is allowed to enter into it, assuming that the promotion is to be to that of chief engineer and the three candidates to be watch engineers. Only one candidate has made any special effort to fit himself for the position and is therefore entitled to it on a strictly business basis.

The one on the left is popular with his mates, a hustler, observing and is liked by the manager, and expects to slide into the job. Being popular with a number of men is no guaranty that he can handle those same men. He will not be taken very seriously, and if he changes his attitude to one of authority they will resent it. Being a hustler is not an essential quality in a chief engineer. His task is to devise ways and means to operate the plant economically and efficiently. His observations are of little value if he lacks the technical knowledge to decide their true significance. The manager has no right to consider his likes or dislikes.

The center candidate is steady, sober and honest, which is probably the reason he has seen long service. Seniority without any indication of ability is no reason for promotion. He has made no effort to fit himself for a better position, therefore has no right to expect promotion. Lacking in ambition, it is not reasonable to suppose he will make an efficient chief. He hopes to fall into the position.

The candidate on the right is qualified in every way, and being a student will be progressive. He, however, is grouchy and will probably have labor trouble; but if the manager understands the principles of coöperation he can explain to this man the effects of grouchiness on the men under him. It is only reasonable to suppose that a man who has the ambition and perseverance to fit himself for the job in every other way will also overcome this fault when he is made to see how objectionable it is. He is the only man who deserves the position; he is trying to climb into it.

S. H. FARNSWORTH.

Chicago, Ill.

[The foregoing assumes one change is to be made; eliminating a fatal error and substituting a desideratum. Suppose the others to be similarly treated?—EDITOR.]

Substitute for "Kilowatt-Hour" Suggested

Electricity as sold is usually dependent upon two factors—the full or maximum demand and the extent or hours of use of the demand.

The demand is the force applied in doing work, and the electrical unit for measuring force is the kilowatt. It is thus described in the A. I. E. E. Electrical Standards:

"Electrical power, which is the rate at which energy is being transformed in a circuit, is expressed by the product of the instantaneous values of electromotive force and current in the circuit. The practical unit is the kilowatt, which is 1000 times the watt."

The amount of force or energy expended in doing work is the product of the average force applied and the duration of time during which the force is applied. The electrical unit is the kilowatt-hour, described as follows:

"The amount of electrical energy transformed in a circuit is measured by the product of the power and the time. The practical unit is the joule, which is equal to one watt-second, the watt-hour and the kilowatt-hour."

It may be found convenient in the sale of electric power to charge on the basis of the kilowatt demand alone, the energy in kilowatt-hours consumed alone, or by a combination of the two methods. Nontechnical men who, through the nature of their business, happen to deal with electrical matters often confuse these terms. The kilowatt and the kilowatt-hour, while directly related, have a different significance, and the oversight or unintentional dropping of the suffix "hour" may create a serious and perhaps costly misunderstanding.

For the best interest of the electrical business it seems that an appropriate substitute for the term kilowatt-hour is highly desirable, and it is fitting that the units of quantity of energy be designated as "kelvins," in distinction of the memorable work of Lord Kelvin. This thought had its inception at the last International Electrical Congress and was at that time recommended for adoption and, not unlike the appeal for the substitution of the term myriawatt for boiler-horsepower (although of a somewhat different application), should receive the indorsement and support of the entire electrical industry.

Pittsburgh, Penn. W. B. WALLIS.

Engineers' Study Course

Heat-Engine Cycles

The series of thermal and mechanical operations through which the working medium of a heat engine passes is called its cycle. The actual cycle of any working engine has back of it an ideal scheme of operation under which the greatest possible proportion of heat could be converted into work. Between ideal and actual performance there is a gap due to secondary losses resulting from imperfections of the real machine.

The essential parts of the ideal cycles of the common types of engine, with both steam and gas as working mediums, are as follows:

1. Reception of heat at high temperature or over a high range of temperature.
2. Lowering of temperature by adiabatic expansion, in which no heat is given to or taken from the substance, so that it performs work at the expense of its initial store of heat energy.
3. Rejection of heat at low temperature or over a low range of temperature.
4. Raising of temperature to the starting point by adiabatic compression, in which the work done upon the substance adds itself to the initial store of heat energy.

Looking at the matter from the side of thermal action, the simplest case is that in which heat reception occurs at some uniform high temperature and heat rejection at some uniform low temperature. The resulting combination of two isothermal (constant temperature) and two adiabatic (no heat transfer) operations constitutes the well known Carnot cycle, which is, thermally, the simplest possible scheme of working. If T_1 is the absolute temperature of heat reception and T_2 the absolute temperature of heat rejection, the efficiency in heat conversion is

$$E = \frac{T_1 - T_2}{T_1}$$

This means that the quantities of heat received, converted, and rejected are respectively proportional to T_1, $T_1 - T_2$ and T_2.

Fig. 1 is a true representation, laid out to scale, of the performance of one pound of air as medium in a Carnot cycle, when working from 2000 to 1000 deg. abs. F., or from 1540 to 540 deg. F. The pressure limits are from 450 to 15 lb. abs. per sq.in. The purpose in giving it is to show how utterly impractical this cycle is as an underlying scheme for a gas engine. The faults are, first, a very weak variation of pressure from the beginning of the stroke at A to the end of the stroke at C; secondly and especially, the vertical narrowness of the inclosed diagram $ABCDA$ coupled with the high total pressures prevailing, as measured above the base line OV. The small mean effective pressure will require a large cylinder for a given power, and the big total pressures will call for a strong and heavy machine and will cause large losses of power through machine friction. Further and finally, isothermal operations could not well be secured with any scheme of internal combustion. The alternative of treating a gaseous medium like the water in a boiler, and supplying heat through a metal wall from an external furnace, has been tried out in the hot-air engines. While not impossible, this plan is of little value practically.

But with steam, as laid out in Fig. 2, the Carnot cycle becomes of distinctly usable form. This is because constant pressure goes with constant temperature in the isothermal operations of evaporation and condensation. The description of Fig. 2 is as follows:

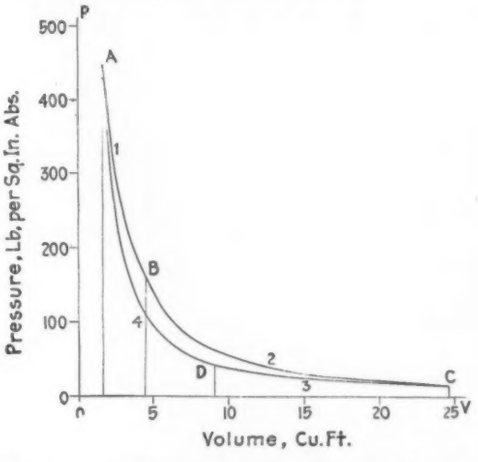


FIG. 1. CARNOT CYCLE FOR ONE POUND OF AIR

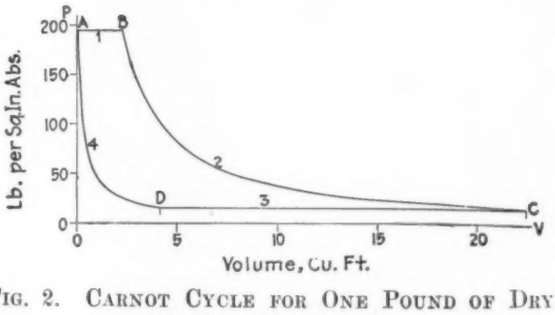


FIG. 2. CARNOT CYCLE FOR ONE POUND OF DRY SATURATED STEAM

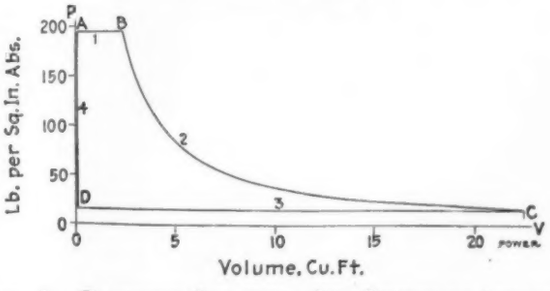


FIG. 3. RANKINE CYCLE FOR ONE POUND OF STEAM FROM FIG. 2.

At A is represented the volume of one pound of water at steam pressure and temperature. Line AB represents the vaporization of this water and the admission into the cylinder of the full volume of steam formed.

With ideal action there would be no loss of heat or pressure in the steam pipe or engine valve and no abstrac-

tion of heat by the cylinder walls. Of course, no material exists of which the thermally neutral cylinder requisite for such action could be made.

Curve *BC* shows adiabatic expansion carried down to exhaust pressure and temperature at *C*. This continues to require the imaginary nonconducting cylinder. To supply heat for work done there is progressive condensation of steam along line *BC*.

Line *CD* represents not so much the expulsion of exhaust steam from the cylinder as the decrease of volume by condensation. This condensation is stopped at such a point *D* that adiabatic compression of the whole charge

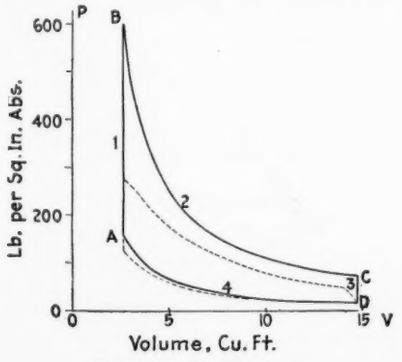


Fig. 4. Ideal Otto Cycle

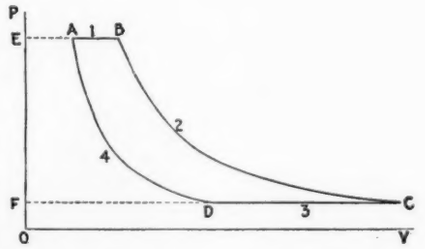


Fig. 5. Brayton Cycle, Used in Gas Turbines

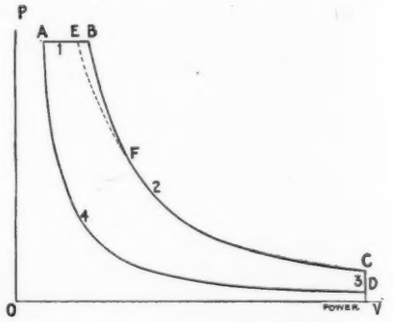


Fig. 6. Diesel Cycle

of the water-steam mixture will bring it to the initial state at *A*.

Now the real cycle of the steam plant conforms to this scheme as closely as actual conditions and materials will let it, with but one exception. This one essential departure lies in the absence of any attempt to raise the feed water to steam temperature by adiabatic compression. Instead, the steam is all condensed, and the resulting water or an equivalent fresh supply is pumped into the boiler.

Modified thus by the omission of adiabatic compression, the Carnot cycle of Fig. 2 becomes the Rankine cycle of Fig. 3. This is the ideal scheme of working which lies back of the actual performance of the steam plant with either piston engine or steam turbine. Such an engine as the direct-acting steam pump falls far short of the ideal output of work per pound of steam. Good plants range from 65 to 75 per cent. of ideal performance.

Working according to the Rankine cycle, an ideal steam plant would get more work from a pound of steam than if on the Carnot cycle, hence would require fewer pounds of steam per horsepower-hour. But the heat required to make a pound of steam increases more rapidly than the work output, so that the Rankine-cycle efficiency is lower.

It is to be borne in mind that the line *AD* at the left-hand edge of Fig. 3 is not identical with the axis line *OP*. The distance between them is the volume of the pound of water, and operation No. 4 is performed by the feed pump. Of course, this operation no longer conforms to the general description in paragraph 2.

Turning now to internal-combustion engines, the cycle most used is represented in Fig. 4. This is in true proportions for certain assumed data, with one pound of gas mixture. The dotted outline shows approximate dimensions of the real diagram. Heat reception takes place with rise of temperature from *A* to *B*, heat rejection with fall of temperature from *C* to *D*. Operations 2 and 4 are adiabatic expansion and compression, as heretofore. In the actual engine the heating at constant volume is pretty well realized. The would-be adiabatic operations are strongly modified by cylinder-wall action, which is strengthened by the water jacket. The ideal cooling at constant volume from *C* to *D* is approximated in mechanical effect by actual exhaust, no matter just how the heat in the exhaust gases is really dissipated into the atmosphere.

The Brayton cycle, Fig. 5, in which heating and cooling take place under constant pressure, is of little practical interest as regards use in piston engines. It is, however, the cycle of nearly all the attempted gas-turbine plants. In the latter there are necessarily two distinct pieces of apparatus—the compressor, whose operation is represented by diagram *DAEFD*, and the turbine, with diagram *EBCFE*.

The Diesel cycle, Fig. 6, calls for little comment. Its heat reception is nearly at constant pressure, although a short isothermal section *EF* is sometimes assumed as a part of the ideal diagram.

The ideal cycle, with its output and efficiency, is not nearly so much used as a standard of comparison for the

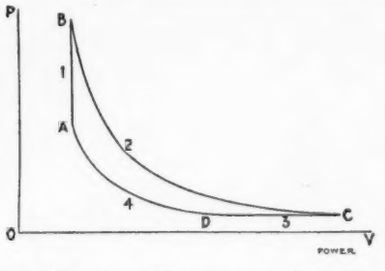


Fig. 7. Cycle of Explosive Gas Turbine

gas engine as it is for the steam plant. One reason is that it is a much larger task to calculate, exactly, the dimensions of an ideal gas cycle than those of the Rankine steam cycle. Roughly, if T_1 is the average absolute temperature during heat reception *AB*, and T_2 the average temperature during heat rejection *CD*, the efficiency is, as per the Carnot cycle,

$$E = \frac{T_1 - T_2}{T_1}$$

But this is only a rough approximation; and a large amount of mathematical work is needed to get an exact value.

In the way of a comparison among these cycles, one

important point will now be noted. From the side of the machine (as against that of thermal action) that cycle is best and easiest to apply effectively in which the least amount of work must be expended in getting the medium up to its high pressure at the beginning of the working stroke—at *A* in all except Fig. 4, and in this figure at *B*. The steam-engine cycle, Fig. 3, shows up best in this respect, although its apparent advantage is partly neutralized by compression in the cylinder. The latter is not an essential part of the cycle, but one of the secondary sources of loss, like cylinder-wall action, etc.

As between gas-engine cycles, the two-part operation *DAB* in Fig. 4 is better than compression clear up to the highest pressure along the curve *DA* in Fig. 5 or *DA* in Fig. 6.

The Diesel engine has advantages which overcome the handicap of excessive compression work. But this handicap is a serious matter indeed for the gas turbine, and one of the chief reasons for its lack of success. It is because of the smaller amount of compression work that the explosive cycle, driving by puffs, has been employed, as in the Holzwarth turbine (POWER, Feb. 9, 1912, p. 191). This cycle is outlined in Fig. 7, and the constant-pressure line *CD*, as in Fig. 5 also, has the practical significance that there is a longer range of expansion than of compression.

American Society of Heating and Ventilating Engineers

The twenty-first annual meeting of the American Society of Heating and Ventilating Engineers, held Jan. 19-22, at the Engineering Societies Building, West 39th St., New York City, was attended by 200 to 300 members and guests, and the attractive program which had been announced was carried out in nearly every detail.

At the business session, held Wednesday afternoon, Jan. 20, reports of the secretary, treasurer and council were received and indicated that steady progress had been made in the special field of the Society and that the ambition to increase its membership to one thousand was not without substantial encouragement.

ANNUAL DINNER OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

PRESIDENT'S ADDRESS

In his annual address, Samuel R. Lewis, the retiring president of the Society, urged upon the members the advantages of following up the actual operation of heating and ventilating plants, especially those of their own design, as information thus gained is highly beneficial in broadening out personal experience and in establishing the relative merits of different systems. Continuing, he said:

> When the designing engineer has more to do with the operation of the plants he designs, there will be an improvement in design. I speak from experience, and believe that this opinion will be shared by others who have had like experience.

An examination of the Society's proceedings discloses many descriptions of new plants, but little information as to their operation or as to the costs of installation or maintenance.

I venture, therefore, to present an analysis of some data. In 1912 two large factory buildings were erected, one in Toledo and one in Detroit, and both were designed by the same architects. The writer designed the heating equipment for both plants.

The character of the construction is identical. There are no basements, but there are some tunnels provided under the first floors for air ducts, service pipes, wiring, etc. The buildings are of reinforced-concrete construction, with solid concrete floors, mushroom type, and 12-in. brick curtain walls. The glass is set in tight, steel frames extending practically from floor to ceiling and from column to column. The ratio of glass to exposed wall is approximately three to one. The roof is of concrete-slab construction, with a cinder fill and tar above.

The Toledo building is heated and ventilated by an all-indirect system, equipped with automatic temperature and humidity control, the humidifying being by means of steam jets. There is no direct radiation whatever, except in a few toilet and service rooms.

The Detroit building is heated entirely by direct radiation, about one-half of the radiation being placed on the side walls and one-half on the ceiling. Great care was taken, however, in placing the radiation on the side walls to provide for a liberal circulation of air behind it. The Detroit building has no automatic temperature control, although good hand regulation is obtainable by shutting off parts of the radiation.

Each plant is equipped with an efficient two-pipe vacuum system. The Toledo plant is unique in its design to the extent that the blast-heating surface is arranged at the bases of the vertical flues and so proportioned that much the same

effect is obtained every day as would be obtained by having direct radiators in the various rooms, since gravity indirect heating is always in effect whenever there is any steam in the radiation. The theory in the design was that the Toledo plant should be economical, comparing with direct radiation by reason of this gravity effect, while not open to the objections inherent in direct radiation when placed against the outside walls. These objections are that the direct radiation interferes with the benches of the workmen, causes local overheating, and is not economical of fuel, since there is an opportunity for a large amount of radiant heat to directly enter the outside wall without appreciably affecting the temperature of the room. The air is handled by steam power, and the cost of air handling is included in the fuel cost.

The Detroit plant, with its direct radiation, is, of course, heated whenever supplied with steam. In March, 1914, information was received from the owners to the effect that the heating plants had proven adequate and satisfactory.

A careful record was kept of the fuel consumed during the season of 1913-14. The following data will serve for comparison:

	Toledo With Ventilation	Detroit No Ventilation
Exposed glass surface	39,520 sq.ft.	13,980 sq.ft.
Exposed wall surface	7,904 sq.ft.	2,796 sq.ft.
Exposed concrete-column surface	7,680 sq.ft.	3,600 sq.ft.
Exposed roof surface	45,880 sq.ft.	29,358 sq.ft.
Exposed ground-floor surface	45,880 sq.ft.	29,358 sq.ft.
Contents	2,460,500 cu.ft.	704,592 cu.ft.
Floor area	178,800 sq.ft.	56,955 sq.ft.
Blast radiation	12,983 sq.ft.	
Direct radiation	negligible	8,905 sq.ft.
Air delivered per minute	138,000 cu.ft.	
Boiler capacity	500 hp.	125 hp.
Cost of coal per season	$3,009.00	$952.00
Fuel cost for heating and ventilating per 1000 cu.ft. of contents per season	$1.22	$1.35
Same per thousand sq.ft. of floor space per season	$16.82	$16.73

So far the evidence is favorable to a blast system as indicating that a large, well built factory building can be heated and ventilated with an efficient, all-indirect plant at less cost per thousand cubic feet of space per season and for nearly the same cost per thousand square feet of floor space per season, as the other can be only heated by plain direct radiation.

The economy of the Toledo plant lies in the form of the building; that is, the Detroit building, being but two stories high, loses heat through the floor of the first floor and through the ceiling of the second floor, whereas the Toledo building, being four stories high, has two intermediate stories which only lose heat around their sides. For this reason there is advantage sufficient in the instance under consideration to make a favorable showing for the blast system.

REPORTS OF COMMITTEES

The report of the committee appointed January, 1914, "to prepare a set of minimum ventilation requirements for public and semipublic buildings which the Society can recommend for legislation," was received with interest.

General Statement of the Committee on Compulsory Ventilation

A correct interpretation of the experimental work which has been carried on in the last few years, relating to ventilation practice, forces certain conclusions:

A. The necessity for adequate ventilation has been emphasized, although the relative importance of certain factors has changed.

B. A high temperature, especially if associated with a high relative humidity, is injurious.

C. The proper relation between air temperature and relative humidity should be emphasized.

D. Air movement in contact with the body materially assists normal heat dissipation.

E. Air supply free from dust, bacteria and other contaminations is important.

In making recommendations for compulsory ventilation laws it is believed that the importance of the following requirements has been amply demonstrated:

1. A minimum allotment per person of floor and air space, based upon the nature of occupancy.

2. A quantitative minimum air-supply requirement.

3. A carbon-dioxide test for determining the quantity of air supply and its distribution.

4. A temperature-range limitation.

5. The removal from the air of injurious substances arising from manufacturing processes or other causes.

6. Air-exhaust requirements for special service rooms (toilets, locker rooms, etc.).

7. Definite requirements regarding the drawing, filing and approving of plans for both new and existing buildings in which ventilating equipments are to be installed or changes in the equipment made.

8. Ample authority to enforce the law without recourse to civil action, and with sufficient operative and financial assistance to care for the clerical, field and technical details incurred by such enforcement.

9. The official body charged with the enforcement of such laws shall have authority to promulgate specific rules and regulations covering details of installation and operation not included in the law. Such rules and regulations must not conflict with the full intent and meaning of the law. (A few such rules are appended to the report.)

The committee decided that it would be impracticable to attempt to draft a model ventilation law with the necessary legal phraseology, as this would require the assistance of an attorney, and would, moreover, call for an extensive building classification which could not be satisfactorily used in the various states, cities or towns where building laws and regulations based on other classifications are now in force. The committee submitted, first (under Section I), the specific report covering general suggestions for minimum heating and ventilation requirements that are applicable to all classes of buildings, and secondly (under Sections II, III and IV), separate sets of more definite requirements for schools and colleges, factories and theaters.

Sections II, III and IV cover three very important classes of buildings which are often the subject of separate legislation. Many other classes of buildings, such as department stores, hospitals and similar institutions, churches, restaurants, police stations, jails, bakeries, laundries, etc., for which the requirements for heating and ventilation are covered by careful interpretation and use of Section I, would be benefited by separate sets of requirements. It was also pointed out that suggestions from the Society, covering practical requirements for the heating and ventilation of street cars and some other public conveyances, are desirable, and that the report could be considerably enlarged to cover these subjects.

The committee strongly urged that educational and cooperative methods of improving heating, ventilation and sanitation conditions be studied, and used as far as possible in addition to compulsory methods.

Various members of the Society and others had assisted in the compilation of these recommendations, and the information had been cheerfully given when available. The committee also reported that acknowledgments were especially due to investigations and recent committee reports concerning the work in New York City and to the ventilation code and experience in the City of Chicago.

The General Suggestions, Section I, of the Committee's Report, applicable to all classes of buildings, to be provided and maintained during occupancy in all rooms and all inclosed spaces in all classes of buildings, are summarized as follows:

Article I—Space per Occupant (minimum requirement)—

Schools and colleges—class, study, lecture and recitation rooms, floor area per occupant in sq.ft.	15
Schools and colleges—class, study, lecture and recitation rooms, cubic space per occupant (volume divided by number of persons) in cu.ft.	180
Primary schools—class and study rooms (pupils under 8 years of age), floor area per occupant in sq.ft.	12.5
Primary schools—class and study rooms (pupils under 8 years of age), cubic space per occupant in cu.ft.	150
Theaters, auditoriums and courtrooms, floor area per occupant in sq.ft.	6
Theaters, auditoriums and courtrooms, cubic space per occupant in cu.ft.	90
Factories, manual-training rooms and other workrooms —floor area per occupant in sq.ft.	25
Factories, manual-training rooms and other workrooms —cubic space per occupant in cu.ft.	250

Minimum space conditions in all classes of buildings or rooms not tabulated shall be reasonable and practical and shall meet the approval of the Department of Health.

Article II—Air Supply (minimum requirement)—

Sufficient outdoor air shall be provided for all occupied rooms or inclosed spaces at all times during occupancy, as may be necessary to meet the requirements of Articles I to XI, inclusive.

The supply of outdoor air for the following classes of rooms shall be positive and based on a minimum quantity of cu.ft. per occupant per hour as tabulated:

Class, study, lecture and recitation rooms in all schools and colleges, cu.ft. per occupant per hour	1800
Courtrooms and auditoriums	1500
Theaters	1200
Factories, manual-training rooms and other workrooms	1500

All air supply for ventilation must be from an uncontaminated source of air from which the dust or other impurities shall be sufficiently removed by washing or otherwise.

Article III—Air Distribution—

The distribution and temperature of the air supply for ventilation shall be so arranged as to maintain the temperature requirement, as stated in Article IV, without uncomfortable drafts, or any draft lower than 60 deg. F., and as a test of proper supply and distribution it shall be required that the CO_2 content shall not at any time exceed 10 parts in each 10,000 parts of air, based upon tests taken in a zone from 3 to 6 ft. above the floor line in the occupied spaces. This requirement may be modified by the properly constituted authority as applying to breweries, water-charging rooms or other rooms where carbon dioxide is liberated in manufacturing processes.

Note—While carbon dioxide in the air, in reasonable quantities, is not considered injurious to health, its presence in occupied rooms is an acccurate measure of the air supply and distribution if no other source of carbon dioxide is present except the occupants of the room.

Article IV—Temperatures—

The temperature of the air in occupied rooms in all classes of buildings, during the periods of occupancy, shall be not less than 60 deg. F., nor more than 72 deg. F., except when the outside temperature is sufficiently high that artificial heating in the building is not required, this requirement not to apply to foundries, boiler or engine rooms, or special rooms in which other temperatures are required or advisable.

Articles V to XIV provide suggestions pertaining to regulations on the subjects of sources of heat; removal of dust,

fumes, gases, vapors, odors, fibers or other impurities; prevention of excessive temperature and humidity; ventilation of special-service rooms; ventilation of toilet rooms; ventilation of cellars, basements and spaces under buildings; authorization to require special ventilation; filing of plans; investment of officials with the right to inspect premises; authorization of officials to close premises after noncompliance with regulations and due notice.

A report was submitted by the committees on the Development of Heating and Ventilating Industrial Buildings, and progress was reported by other standing committees.

In a brief paper presented by A. M. Feldman on an experiment with ozone as an adjunct to artificial ventilation at Mt. Sinai Hospital, New York City, the author recited details of experiments and observations upon which he unhesitatingly recommended the use of ozone as an efficient deodorant, which he believed was beneficial in general improvement of air conditions when properly used, and harmless in physiological effects.

The observations of the author precipitated some discussion of the old question of whether the action of ozone was a destruction of baneful conditions or a mere masking of odors. Dr. M. W. Franklin ably described experiments made by him which demonstrated by comparatively simple chemical processes and analyses that compounds consisting of most disagreeable and deleterious exhalation are so broken up by ozone as to be destroyed and not merely compensated.

A well illustrated paper was presented by D. D. Kimball, author of Part I, and George T. Palmer, chief of investigating staff, author of Part II, on "Results of Physiological and Psychological Observations during the First Year's Experiments" by members of the New York State Commission on Ventilation. The investigation was made possible through the generosity of Mrs. Elizabeth Milbank Anderson, who gave to the Association for Improving the Conditions of the Poor of New York the sum of $550,000 for various phases of social investigation, $50,000 of which is to be expended in an investigation of the problems of ventilation.

This commission, consisting of Professors C. E. A. Winslow, F. S. Lee, E. L. Thorndike, E. B. Phelps, Dr. James A. Miller and D. D. Kimball, was organized early in the summer of 1913, and steps were immediately taken to provide a laboratory equipment for the conduct of the studies and the experiments. The experimental plant was installed in rooms of the biological laboratories of the College of the City of New York. It was aimed to provide atmospheric conditions with temperatures from that existing out of doors or less up to 100 deg. F. in zero weather, with humidities varying from the saturation point to practically nothing. The illustrations and descriptions of the apparatus and methods employed for creating the desired conditions, selection of subjects, tests and data are all of highest scientific interest to physiologists, employers, heating and ventilating engineers, and the public generally, in determining the influences of different air conditions and advantages of controlled systems of ventilation.

In the first experiment, the efficiency in mental work of four subjects, young men about 18 years of age, students of the College of the City of New York, was compared in five different atmospheric environments, viz.: 68 deg. F. and 50 per cent. relative humidity with ample air supply (about 45 cu.ft. per min. per person); and the same temperature and humidity, no air supply (i.e., a stagnant condition); 86 deg. F. and 80 per cent. relative humidity with ample air supply, and also with no air supply; and 86 deg. F., 80 per cent. humidity, no air supply (a stagnant condition but with small electric fans blowing air on the faces of the subjects).

The experiments were thus planned to give information on the subjects' efficiency in (1) a hot moist room as compared with a cool room, (2) a room with ample supply of fresh outdoor air as compared with a room in which no air at all was supplied, and (3) a hot moist room where relief was afforded by the moving air from electric fans. The relative effects were determined by (1) measurement of mental accomplishments, (2) measurement of physiological responses and (3) recording the opinion of the subject as to state of comfort.

In addition to the above six, other sets of tests were conducted, with conditions varied to correspond with extreme conditions of outdoor and indoor atmosphere during the warmest season of the year.

The results of each series of experiments bring out strongly the fact that temperature, and not chemical composition of the air, exerts the greater influence on the physiological responses and that no distinct differences exist between fresh and stagnant air, as far as pulse and blood pressure are concerned; that more food is eaten at the lower temperatures, and the increased consumption on the days with air supply is even more striking; that when the subjects were urged in their work, about one-third more was done at 68 deg. than at 86 deg. F.; that no falling off of judgment was indicated by exposure to the hot conditions, the slightly better score even favoring the warm days and the days with air supply; that room temperature fails to influence mental efficiency, although the feelings of the subject differ materially, favoring the lower temperature. The results also showed that while high temperature and even 75 deg. measurably affected certain physiological reactions of the body, mental processes were not impaired. In fact, with the same relative humidity (1) the 75-deg. condition is somewhat preferable for tasks involving deep concentration, such as mental multiplication; (2) the 68-deg. condition is slightly more desirable for combined mental and motor tasks such as typewriting; (3) that the difference between the two temperatures is practically negligible for maximum effort tests involving mental processes similar to those used in additions of columns of figures, and that there is no choice between these two variables so far as the physical comfort of the subject is concerned.

Application of the inclination-to-do-work test to physical studies was instituted to analyze the effects of the 68-deg. and 75-deg. temperatures and the importance of air supply. These tests consisted of (a) accomplishment of voluntary physical work, (b) variations in appetite, (c) effect of extreme exertion on rate of pulse recovery, and (d) effect on various physiological responses. The results of the work tests show that when left free to occupy their time either at work or rest, the subjects performed 15 per cent. more work at 68 deg. than at 85 deg., and that 2 per cent. more work was done when air was supplied.

In their summary of results the authors state that it is difficult at this time to arrive at any sweeping conclusions as to the importance of different ventilation factors. The influences of humidity have not been studied at all to date. The first year's work of the commission has, however, developed these facts:

1. Temperature within the range from 86 deg. to 68 deg. F. has a marked effect on certain physiological responses.

2. Stagnant air, lacking a definite disagreeable odor but containing all the products of the exhaled breath, including carbon dioxide in excess of 30 parts per 10,000, is objectionable in a manner as yet unknown but demonstrated by a lessened desire for food, but otherwise shows no debilitating effect on the mental process nor on the various physiological reactions which have been studied in these experiments.

ELECTION OF OFFICERS

Officers for the year 1915, as reported by the nominating committee, were elected as follows: President, Dwight D. Kimball, New York; first vice-president, Harry M. Hart, Chicago; second vice-president, Frank T. Chapman, New York; treasurer, Homer Addams, New York. Managers—Frank Irving Cooper, Boston; Dr. E. Vernon Hill, Chicago; W. M. Kingsbury, Cleveland; Samuel R. Lewis, Chicago; Frank G. McCann, New York; J. T. J. Mellon, Philadelphia; Henry C. Meyer, Jr., New York; Arthur K. Ohmes, New York.

The first paper considered at the evening session of Jan. 20 had for its subject "The Centrifugal Fan," by Frank L. Busey, and had been prepared for presentation before the Society just previous to the death of its author. The paper was read by W. H. Carrier, who stated that a very considerable portion of the data consisted of results of the author's personal investigations. (Most of the leading features of the paper are given by the author in an article by him, which was published in the Aug. 11, 1914, issue of "Power," pp. 200-204.) Several members spoke in the highest terms eulogistic of the author's attainments and the work which he did as a valuable member of the Society. The paper was ordered to be printed in the "Transactions," and by a rising vote of all present the thanks of the Society were tendered to Mrs. Busey for her act of providing the Society with the manuscript.

A paper on "Engine Condensation," by Perry West, elicited a spirited discussion, in which several members took issue with the author's deductions leading to the statement:

It will be seen from the foregoing that in passing high-pressure steam from a boiler through a system of piping and thence through a reciprocating engine, a considerable heat loss is encountered, which usually results in a considerable percentage of condensation in the exhaust. I should say that with simple engines this would run between 15 per cent. and 20 per cent. This means, of course, that there is never as much steam available for the heating system as is started with at the boiler, but just this amount of condensation. Besides this, the steam is in a very moist condition, due to the presence of this water.

David Moffat Myers, the author of the succeeding paper, presented by discussion and in his paper, "The Heating Value of Exhaust Steam," statements and conclusions which were considerably at variance with the deductions of Mr. West, claiming that the latter's method of estimating heat remaining in the exhaust of an engine were unwieldy, and when estimates are based on data which have been established for

the thermal efficiencies of engines, the average of Mr. West's estimates for the heat loss of simple engines would be found about 8 per cent. too high.

"A Study of Heating and Ventilating Conditions of a Large Office Building" was the subject of a paper presented jointly by C. E. A. Winslow and G. F. Maglott, in which the authors call attention to the facts that the progress of the art of heating and ventilation has been seriously retarded by the gap which, unfortunately, often exists between design and operation. Excellently planned systems may fall on account of changes in conditions of occupation or carelessness in upkeep and management; while on the other hand, operation sometimes reveals shortcomings in design which should be instructive in the planning of future installations. Careful studies of actual results obtained are none too common. The authors present such a study of a large business office building in New York City, heated in the main by direct steam radiation, with certain rooms on the lower floors in part indirectly heated by plenum air supply.

A scientific investigation showed, as all too often is the case, that both the heating and the ventilating systems had been allowed to fall into such disrepair and to become so ill adjusted to present needs as to fall far short of realizing the purposes for which they were designed. It is just such conditions as these which constantly bring discredit upon the art of heating and ventilation, and they are conditions which can only be brought to light by comprehensive engineering and sanitary study of actual operation.

Other papers presented and discussed were: "Studies in Air Cleanliness," by G. C. and M. C. Whipple; "Problem of City Dust," by R. P. Bolton; "Cinder Removal from the Flue Gases of Power Plants," by C. B. Grady; "Recirculation of Air in a Minneapolis School Room," by Frederic Bass; "Comparative Tests of Various Types of Exhaust Ventilators for Sleeping Cars," by Dr. T. R. Crowder; "Ventilation of Industrial Plants," by T. Graham-Rogers, M. D.; "Test of a Cast-Iron Sectional Down-Draft Boiler," by C. A. Fuller; "Crude Oil Fuel," by H. S. Haley; "Some Phases of Room Heating by Means of Gas Burning Appliances," by George S. Barrows; "Rational Methods Applied to the Design of Warm Air Heating Systems," by Roy E. Lynd; "Tests on Threading Steel and Wrought-Iron Pipe," by C. G. Dunnells; "Capacities of Steam Pipes at Different Pressures," by James S. Otis.

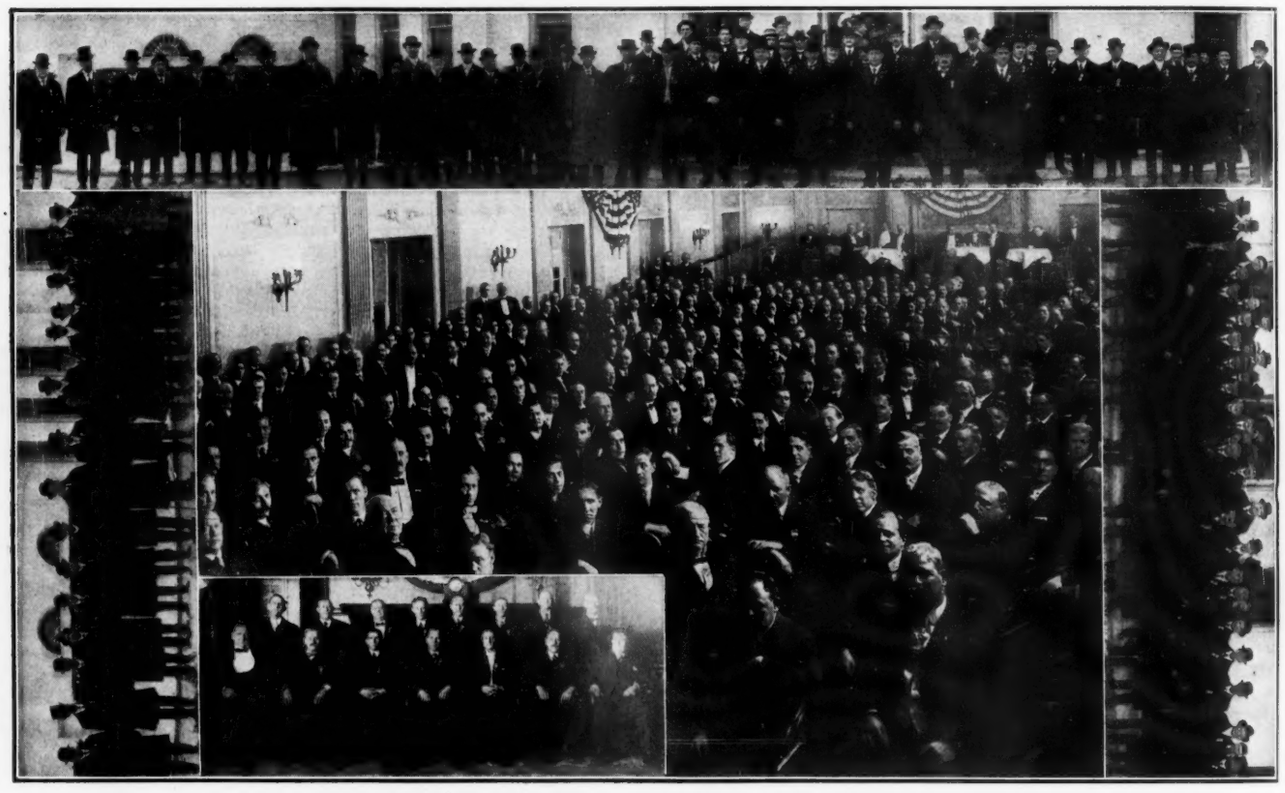
ENTERTAINMENT

The entertainment committee provided a program for out-of-town members and guests, which included social sessions, shopping tours for the ladies, theater parties and visits to points of interest. The annual dinner, which was held at the Hotel McAlpin on the evening of Thursday, Jan. 21, was attended by nearly 200 members and guests and proved to be one of the most enjoyable events in the history of the Society.

National Marine Engineers' Convention

The National Marine Engineers' Beneficial Association of the United States of America convened in its fortieth annual session on Monday, Jan. 18, at 10 a.m., at the Raleigh Hotel, Washington, D. C. The following officers occupied their respective chairs: William F. Yates, president; George H. Bowen, second vice-president; Charles N. Vosburgh, third vice-president; George A. Grubb, secretary; Albert L. Jones, treasurer.

The several daily sessions of the delegates were from 9:30 a.m. to 1:30 p.m. There were present 60 delegates, representing 115 votes from all of the large lake and river cities of the United States. The financial report showed the organization to be in a prosperous condition. Many matters of special interest to the association were discussed and disposed of with harmony and dispatch.



THE MARINE ENGINEERS' BENEFICIAL ASSOCIATION'S FORTIETH CONVENTION

Group outside the White House after being received by the President—The new National Officers—The Smoker at the Raleigh Hotel

On Thursday morning an adjournment was taken by the delegates to permit of the convention visiting the White House to be presented to President Woodrow Wilson. There was a theater party on Monday evening to Keith's Vaudeville House for everybody, and on Wednesday evening there was one exclusively for the ladies. The smoker on Thursday night tendered to the engineers by the Supplymen was the big event of the convention, and was heartily enjoyed by all. Fully 400 delegates and invited guests assembled in the ballroom of the Raleigh, where the "New York Bunch" of entertainers made things lively, and kept the audience in good humor for the entire evening. Good things to smoke and drink were served plentifully.

At the session on Wednesday morning the following national officers were elected: A. Bruce Gibson, president, San Francisco, Calif.; E. M. Roberts, first vice-president, New York City; C. N. Vosburgh, second vice-president, New Orleans, La.;

William C. Wilson, third vice-president, Philadelphia, Penn.; George A. Grubb, secretary, Chicago, Ill.; Albert L. Jones, treasurer, Detroit, Mich.

The advisory board includes: Thomas L. Delahunty, New York City; George H. Willey, Boston, Mass., and Robert L. Goelet, Norfolk, Va.

The trustees of the "American Marine Engineering" comprise Clinton E. Thurston, Norfolk, Va.; Joseph G. Myers, Charleston, S. C., and William Murray, New York City.

The forty-first annual convention will meet at Washington, D C., the week beginning Jan. 17, 1916.

General Electric Co. Exhibit for Panama-Pacific Exposition

The exhibit of the General Electric Co. in the Transportation Building at the Panama-Pacific International Exposition will comprise electric locomotives for various classes of service, including steam-railroad electrification, railway motors and all kinds of apparatus and accessories for electric railways, signal accessory electric devices, electric apparatus and equipment for railway shops, electric illumination for cars and shops, etc.

One of the electric locomotives is one of four recently built for the Butte, Anaconda & Pacific R.R. and is a duplicate of the original 17 units put into service in 1913. These are the first 2400-volt, direct-current electric locomotives ever built. Each unit weighs 80 tons, and two are coupled together for freight service hauling trains of 4600 tons at 16 miles per hour up a 0.3 per cent. grade, and at 21 miles per hour on level track. Two passenger locomotives, operating as single units on this system, are geared for a maximum speed of 45 miles per hour on level track.

Down with the Archaic Boiler Horsepower

We are rapidly drawing away from the horsepower method of rating boilers. This has come about through the working of two different tendencies, both of which diminish the value of such a statement of boiler capacity. In the first place, there no longer exists any particular equality between the horsepower of a boiler and the amount of engine power which it may be expected to serve, although at the time of the adoption of the present unit, in 1876, it was given a value about equal to the average steam consumption per horsepower of the engines exhibited at the Centennial Exposition, on the assumption that this would approximate average conditions at that time. Modern engines have so far improved in economy that it is now possible for one boiler horsepower to serve from two to three engine horsepower of connected load under favorable circumstances. There is, moreover, another influence at work to lessen the value of the horsepower rating—namely, the growing demand for greater and greater boiler output per unit of heating surface—so that it is no longer a matter of special novelty to read test returns of boilers in regular operation at upward of 200 per cent. of what a few years ago would have been considered a proper performance.

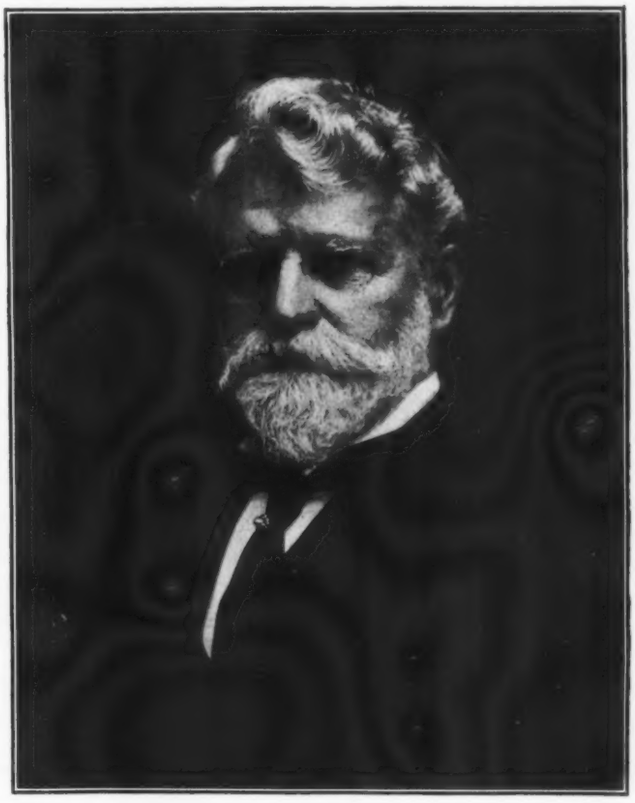
The result of these two changes in power-plant economics is to make it more and more necessary to plan boiler plants on a heating surface and not a horsepower basis. The designing engineer first determines the rate at which he expects to be able to work his heating surface, with the character of coal, draft, setting, etc., which he expects to utilize; that is, he sets a figure for the amount of water which he may expect to evaporate on each square foot of heating surface in the particular plant he has in mind. It is then only necessary to add the combined water rates of the different steam-consuming devices and divide by the evaporative rate to arrive at the total heating surface, which he can divide among the proper number of boilers.

When an essentially nontechnical buyer of boilers is obtaining competitive bids from boiler makers; he is apt to think and talk in terms of dollars per 100 or 150 (or some other number) horsepower. He naturally assumes that this is a proper basis upon which comparisons may be made. He will of course be disappointed if, having purchased the boiler from the lowest bidder, he finds to his surprise that this builder has bid on a boiler rated at 10 sq.ft. to the horsepower, while perhaps his engineer in deciding on the necessary size has calculated on 12 sq.ft. to the horsepower rating. This is very confusing to the owner who is not an engineer or who is not familiar with the diversity which exists among boiler makers as to the proper rate of evaporation to use as the foundation for a catalog rating. It is not at all uncommon for the condition outlined above to come about, resulting in the purchase of a boiler 20 per cent. smaller than either the buyer or his engineer desired.—"The Locomotive."

The Engineering Foundation

The ceremonies inaugurating the Engineering Foundation were held Wednesday, Jan. 27, at 8:30 p.m., in the auditorium of the Engineering Societies Building in New York City. The name, The Engineering Foundation, has been given to a fund "to be devoted to the advancement of the engineering arts and sciences in all their branches, to the greatest good of the engineering profession and to the benefit of mankind." The administration of this fund will be intrusted to the Engineering Foundation Board elected by the trustees of the United Engineering Society, the holding corporation of the Engineering Societies Building, and composed of eleven members, two each from the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers, two members chosen at large, and the president of the United Engineering Society, ex-officio.

Gano Dunn, president of the United Engineering Society and past-president of the American Institute of Electrical



AMBROSE SWASEY

Engineers, presided, and announced for the first time the name of the donor of the initial gift of $200,000—Ambrose Swasey, who is widely known as a member of the firm of Warner & Swasey, of Cleveland, Ohio, prominent machine-tool builders and the foremost builders of telescopes in the world. Among the instruments which they have designed are the famous Lick, Yerkes and United States Naval Observatory telescopes, as well as the 72-in. reflecting telescope for the Canadian Government, which is now under construction. In addition to his engineering achievements, Mr. Swasey is known for his practical efforts toward scientific education and the advancement of the profession. His gift for the establishment of The Engineering Foundation is in line with these undertakings, which may be destined to outlast his fame as an engineer.

In response to the ovation given Mr. Swasey at this time, he arose and made an acknowledgment of his appreciation of the spirit in which the announcement had been received. Other speakers of the evening were: Dr. Henry S. Pritchett, president of the Foundation for the Advancement of Teach-

ing; Dr. Robert W. Hunt, past-president of the American Institute of Mining Engineers; Charles MacDonald, past-president of the American Society of Civil Engineers; and Dr. Alexander C. Humphreys, past-president of the American Society of Mechanical Engineers.

Following the ceremony a reception to Mr. Swasey was held at the platform of the auditorium. A testimonial dinner to him was given on the preceding evening by the president and board of trustees of the United Engineering Society, at which speeches were made by leading engineers representing the civil, mining, mechanical and electrical branches of the profession, which helped to further cement the close relationship existing and gave promise of hearty coöperation in the future on all matters affecting the profession in general.

Rolling-Mill Engine Wrecked

Early in January the compound condensing engine driving a train of hot rolls at one of the plants of the American Sheet and Tin Plate Co., at Chester, W. Va. (near East Liverpool, Ohio), was badly wrecked, caused by the breaking of the strap on the crosshead end of the connecting-rod.

When freed from the rod the crosshead and low-pressure piston were driven through the low-pressure cylinder, breaking it beyond repair, also the distance piece between the high- and low-pressure cylinders. The high-pressure cylinder was not so severely damaged, because the studs which held it to the bedplate gave way and allowed the cylinder to recede. It was torn from the bedplate and its steam connections at the throttle and receiver pipe.

The engine was built by C. & G. Cooper and had been in use about 14 years. It was 26&54x60-in. and ran at 65 r.p.m., carrying a 22-ft. flywheel weighing about 60 tons, and was geared to a shaft driving six hot mills. A steam pressure of 140 lb. was carried, exhausting into a Worthington condenser.

Fortunately, no one was injured, but the mill will be shut down for fully four weeks, during which time about 500 men will be idle. Our representative was, unfortunately, unable to procure photographs, as the work of clearing away the wreckage and reconstructing the engine was begun at once and all haste was made to get the mill in operation again.

PERSONALS

F. W. Rose, of the firm of Rose & Harris, engineers, Auditorium Building, Minneapolis, has been elected secretary and treasurer of the Minnesota section of the American Society of Mechanical Engineers.

Errett L. Callahan, for the past six years manager of the new business department of H. M. Byllesby & Co., Chicago, Ill., has resigned that position to become Chicago district manager for the Westinghouse Lamp Co.

David A. Wright, for several years with the Yale & Towne Manufacturing Co., of New York, as district manager in the West, has engaged in business for himself as manufacturers' agent, at 149 South Dearborn St., Chicago, Ill. He is specializing on labor-saving and pneumatic machinery, cranes, hoists and trolley systems.

E. P. Roberts, commissioner of smoke abatement, Cleveland, Ohio, has tendered his resignation, to take effect Feb. 1, and will resume business as a consulting engineer, with temporary address 2053 East Ninety-sixth St., Cleveland. In addition to general power-plant engineering as heretofore, he will make a specialty of smoke abatement.

Dr. Edward Weston, of Newark, N. J., has been presented with the ninth impression of the Perkin medal, given for distinguished service in chemistry and electrochemistry. The ceremony took place on Jan. 22, at the Chemists' Club, Dr. G. W. Thompson presiding. The medal was presented by Doctor Chandler, senior past-president of the Society of Chemical Industry, after briefly reviewing the career of the recipient.

ENGINEERING AFFAIRS

The Western Society of Engineers, Chicago, has elected the following officers for the year 1915: President, W. B. Jackson; first vice-president, Ernest McCullough; second-vice president, Charles B. Burdick; third vice-president, P. B. Woodworth; treasurer, C. R. Dart; trustees, F. E. Davidson (one year), H. S. Baker (two years), O. P. Chamberlain (3 years).

Railroad Night for Chicago Section A. S. M. E.—Jan. 8 was railroad night for the Chicago section of the American Society of Mechanical Engineers. As usual, it was a dinner meeting held in the Louis XVI room of the Hotel La Salle. There was a large attendance and a number of able speakers. S. G. Neiler presided. The subjects discussed were: The Locomotive Superheater, Locomotive Stokers, and Railway Economics. The subject first named was introduced by R. M. Ostermann, of the Locomotive Superheater Co. C. F. Street, president of the Locomotive Stoker Co., gave some statistics on the cost of operation, when using stokers and outlined the advance that had been made in this field. Railway Economics was discussed at length by W. A. Smith, president of the "Railway Review."

Technology Clubs Convention—The Technology Clubs Associated, an organization of former students of the Massachusetts Institute of Technology, will hold a reunion in Pittsburgh Feb. 19 and 20, at the invitation of the Pittsburgh Association. The main features will be: Class luncheons the first day; course luncheons the second day where discussion of the various curriculums will be undertaken and where graduates, in the light of their later experiences, will be invited to criticize their own courses of instruction; and the banquet Saturday evening, when addresses will be given by President Richard C. Maclaurin and probably President A. Lawrence Lowell, and two other speakers of international prominence whose names are to be announced later. All alumni and former students of the institute are invited.

International Engineering Congress—The American Society of Mechanical Engineers has issued a circular letter to its membership, urging individuals to subscribe to the International Engineering Congress to be held in San Francisco in connection with the Panama-Pacific International Exposition, Sept. 20 to 25, 1915. As one of the five national societies in the hands of the representatives of each of which the Congress is placed, it is urged by the mechanical engineering society that its members should feel responsibility and give their fullest support to the Congress. The fee for membership is $5, which entitles a member to the index volume which covers general proceedings, indexes and digests, and any one of nine other volumes which are published or to be published, as follows: Vol. 1, The Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Railways; Vol. 4, Municipal Engineering; Vol. 5, Materials of Engineering Construction; Vols. 6 and 7, Mechanical and Electrical Engineering; Vol. 8, Mining Engineering and Metallurgy; Vol. 9, Naval Architecture and Marine Engineering; Vol. 10, Miscellaneous.

TRADE CATALOGS

Skinner Engine Co., Erie, Penn. Catalog. Universal Unaflow engine. Illustrated, 28 pp., 8½x11 in.

The Emerson Electric Mfg. Co., St. Louis, Mo. Catalog No. 6700. Electric fans. Illustrated, 48 pp., 7x10 in.

Kennedy Valve Mfg. Co., Elmira, N. Y. Catalog. Gate, globe, angle, radiator and corner valves. Illustrated, 124 pp., 6x9 in.

B. F. Sturtevant Co., Hyde Park, Mass. General Catalog No. 195. Fans, exhausters, blowers, engines, steam turbines, etc. Illustrated, 116 pp., 6½x9 in.

Armstrong Cork & Insulation Co., Pittsburgh, Penn. Booklet. "Permanent Fortifications." Nonpareil corkboard insulation. Illustrated, 8 pp., 3½x6 in.

CONTRACTS TO BE LET

TREASURY DEPARTMENT, Supervising Architect's Office, Washington, D. C., January 5, 1915—Plans and specifications are now approaching completion for a central heating, lighting and power plant, to be erected in this city under the direction of this office. These plans and specifications will be ready for delivery on or after January 15. Bids may be submitted for the entire work or for any one of the following sections: Power plant building complete, with steel stacks; boilers; generating apparatus; pumping equipment; condensers; coal and ash handling apparatus; steam and water piping; switching gear; tunnels; substation apparatus, etc. Prospective bidders should immediately submit to this office applications for plans and specifications, stating the portions of the work upon which they desire to bid. If it appears that the applicant is in a position to bid on all of the work in any one of the sections of the project, or upon the entire work, the plans and specifications will be forwarded. No plans or specifications will be furnished sub-bidders or others not in a position to submit a bid on all of the work comprised in at least one section. The Department will be able to allow only about 15 days for the preparation of estimates. At the time plans and specifications are forwarded to bidders the date for the opening of bids will be stated, and this date will not be extended. O. WENDEROTH, Supervising Architect.